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OF THE

TEA RESEARCH INSTITUTE

OF CEYLON.

Edited by

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THE TEA RESEARCH INSTITUTE

St. Coombs, Talawakelle,

Ceylon.

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CORRIGENDA.

Tea Quarterly, Vol. XXII, Part II, 1951,

Page 54, Line 6.

For " given Perenox and Shell copper fungicide."
Read " given by Perenox and Shell copper fungicide "

Line 16.

For " sodium ethylene his dithiocarbamate : "
Read " sodium ethylene bis dithiocarbamate : "

Line 39.

For " given Perenox and Shell copper fungicide."
Read " given by Perenox and Shell copper fungicide."

Page 55, Line 7.

For " (*c*) Zinc ethylene bis ithiocarbamate "
Read " (*c*) Zinc ethylene bis dithiocarbamate "

Page 77, Line 13.

For	" $6CO_2$ (Carbon dioxide)	+	$6H_2O$ (Water)	=	$(6CH_2O)_6$ (Glucose)	+	$6O_2$ " (Oxygen)
Read	" $6CO_2$ (Carbon dioxide)	+	$6H_2O$ (Water)	=	$(CH_2O)_6$ (Glucose)	+	$6O_2$ " (Oxygen)

Page 84, Line 10.

For " (1) The size of the orific."
Read " (1) The size of the orifice."

Page 87, Line 9.

For " Sub-Station, Gonakelle Estate, Passara, where it is hoped "
Read " Sub-Station, Gonakelle Estate, Passara, when it is hoped "

THE TEA QUARTERLY.

VOLUME XXII. JUNE, 1951. PART II.

* THE MAINTENANCE OF FERTILITY IN TEA SOILS.

By

J. Lamb.

Most of the lectures or talks I give to Planters' Association meetings are on highly specialised aspects of tea planting or tea manufacture. On this occasion, more especially because it is your Annual General Meeting, I have prepared a formal lecture of a more general and fundamental nature than usual. I feel it is desirable every now and again to take a broad view of tea planting as a branch of agriculture in general rather than to persist with nothing but myopic glimpses of tea in particular.

Man's ability to mechanise and to increase agricultural production per man hour has far exceeded his ability to increase the yield of agricultural produce per acre. The manufacture and mining of concentrated plant nutrients has enabled mankind to overcome some of the initial difficulties of maintaining the productiveness of agricultural land, but our efforts to increase the fertility of our soils are not keeping pace with the fertility of man himself. William Vogt, in his provoking book, "The Road to Survival", maintains that the human race has been living on a capital of fertility stored on the surface of the earth and that we are exploiting this capital at a rate which threatens to reduce the scale of living to which we have been accustomed in the last century, since mechanisation increased our ability to exploit. This thesis cannot be lightly dismissed and I propose to discuss it in some detail.

The sun is the fundamental source of energy in all forms of life on the earth. Plants absorb this energy and, with it, transform carbon dioxide, water and minerals into vegetable matter. Animals are entirely dependent on plants for their nutrition, since they cannot synthesise their food directly from mineral elements. Lower forms of plants, such as bacteria and moulds, reduce dead tissues to forms in which they can either be used again as plant food or stored for future use in the form of humus. Specialised bacteria and moulds also help to control plant and animal populations by causing premature death when overcrowding occurs. The most elementary speculations on biology immediately lead us to the question of balance. The expression "The balance of nature" is no idle fancy; none but fools will scorn it. To understand the balance in all the subtleties is, however, a task which is beyond the wisest of us.

Carbon dioxide is freely available all over the earth, but the amount of sunshine and water available to plants varies widely, and has led to the evolution of an enormously wide range of plants, ranging from those which have adapted themselves to the minimum amount of light and warmth, such as arctic plants, to the cacti and the euphorbias which can survive in burning sunshine with the minimum of rainfall. In Ceylon, we have all the light, warmth and rain we need; in fact we have an excess. The amount of heat available at the surface of the earth in tropical regions causes a rapid decomposition of rock but, in the monsoon areas where rainfall is heavy, the products

* *Lecture delivered to Dimbula, Dickoya and Uva District Planters' Associations.*

of decomposition tend to get washed away. Nature's own solution to these conditions is the tropical rain forest, which breaks the fall of rain and protects the soil from excessive light and heat. Humus and surface mulch then form which, in turn, help to store nutrients, especially water, and also to regulate the flow of excess water into natural drainage channels at a rate which does not carry away the soil as it weathers from the parent rock formations.

Storms of sufficient violence to wash away soil in natural rain forest areas do occasionally occur and the purpose of these I cannot pretend to explain. Neither can I explain fires which sometimes destroy the tropical rain forests but the process of regeneration appears to be fairly obvious. Grasses quickly become established in fired and eroded areas and maintain or even establish conditions in which trees can once again take over. The patnas are undoubtedly part of a natural succession and become temporarily established when fire, or fire plus erosion, destroys the natural forest. Forests cannot, of course, become established until there is an adequate depth of soil, and grasses will be found where the depth of soil is not sufficient for trees. Geologically, Ceylon soils are old, so I have omitted mention of the earlier stages of soil formation, but we can still see these initial stages on slab rock where mosses and lichens are the advanced guard of the grasses.

Tea was planted in place of the rain forests or patna where the depth of soil was already adequate for the growth of trees. Tea is in itself a forest plant and grows in mixed tropical rain forests with a high cover—often, I believe, of *Albizzia* species. It is therefore a suitable crop for the soil with which we are concerned and we will now consider the factors which are involved in the fertility of the soil so hardly won from granite rocks, and so carefully preserved by natural successions of plant growth. They are :—

1. Light and temperature.
2. Water supply.
3. Air supply.
4. Supply of plant nutrient.
5. Various injurious factors.

I will deal with each factor in brief outline and at the same time attempt to assess the importance of each in planting practice.

(1) **Light and Temperature.** The species of tea plants grown in commerce have become adapted to a wide range of temperature condition and withstand both moderately high and moderately low temperatures but cannot survive long periods of frost. So long as tea gives sufficient cover to the soil and maintains the conditions found on the forest floor, no particular harm is done by high temperatures. However, forest soils exposed to direct sun rapidly lose their cover of mulch and, when the soil temperature rises unduly, organic matter in the soil is rapidly destroyed. A great deal of work has been done in Malaya on these aspects of tropical soils and when I was in Trinidad I assisted in some experiments in which belts of natural rain forest were felled every year in order to determine the rate of oxidation of organic matter in exposed soils. During my time, the oldest felled belt was only 3 to 4 years old and the organic matter was already showing a very marked fall according to the method of analysis I employed. It is a very complicated subject and much remains to be done, but I hope that Dr. Haworth will be able to devote the greater part of his time to soil problems. One of the reasons for the experiment I have just mentioned was that the Forest Department in Trinidad were finding great difficulty in re-establishing teak in areas which had been clear-felled during the 1914—18 war, and I am frankly alarmed by the possible difficulties in replanting tea in areas of exposed soils. We already have an experiment under way to determine the effect of grasses on reconditioning and

replanting. From the practical point of view we must keep our soils covered by encouraging the maximum spread of our bushes, by high shade, and by growing green manures after pruning until they are crowded out by the tea again. Ground covers and selective weeding can be employed where considerable exposure has already occurred, but they must be regarded as temporary and rather extreme measures.

The tea plant does not need full exposure to sunshine to obtain its requirements of light. Plants grown in shade normally carry large amounts of foliage to increase their light absorbing power, which, in turn, increases soil cover and the ability to absorb nutrients. The removal of shade from tea, although it may temporarily increase the rate of growth due to light stimulus will tend to upset the balance between the amount of maintenance foliage, soil cover and nutrient absorption. The long term effects of such a change of agricultural policy are unknown and involve unwarranted risks.

2. **Water supply**

3. **Air supply.**

4. **Nutrient supply.**

These three factors are taken together because I must limit this lecture to the more important points. The main aspect I wish to stress is the importance of organic matter in the soil and its effect in maintaining the conditions essential for the growth of a plant such as tea. First and foremost I wish to mention the effect of organic matter on the physical condition of the soil — primarily the maintenance of what is known as "crumb structure".

It is difficult to define crumb structure, especially in tropical soils. Most good agriculturists know, by experience, when a soil is in good heart. Sir James Scott Watson says of temperate conditions "A soil with a good crumb structure is friable and handles well. It does not go sticky when squeezed, nor does it disintegrate into small pieces like sand. It holds water without becoming water-logged or sad, and works well with implements. To produce this good crumb structure it is essential to have organic matter of some sort."

Certainly even with tropical soils, a soil in good heart holds water well and does not dry out as quickly as a structureless soil. Soil structure enables free drainage, whereas a poor soil tends to pack when wet. With good structure goes free aeration and the minimum of cultivation is then necessary to provide an adequate air supply. A sticky soil compacts and impedes the supply of air to roots and to micro-organisms. Cultivation tends to destroy structure, so at all costs avoid plain forking. The best advice I can give you is, if possible, only to fork when there is organic matter and manure to fork in. When forking is carried out, fork deeply but avoid any lifting action which will break the larger roots of the tea bush.

Dr. Haworth is finding many indications that our Ceylon soils have a comparatively poor ability to hold nutrients. The technical expression is that they have a low base exchange capacity. The clay fractions in which this vital function is centred, is in any case apparently low, apart from which the kaolinitic types of clay formed from granite rocks do not hold ammonium and potash ions as well as many other types of clay. The preservation of organic matter, which also has the ability to hold nutrients, is therefore, in the case of our tea soils, of paramount importance.

The finer particles in our soils also tend to wash down to the limit of the depth of forking and to form a hard pan which the roots of the tea bush cannot penetrate. Since we cannot cultivate with sub-soiling tools the deep

rooting shade tree is an essential companion to the tea bush, apart from all other benefits it may confer in the form of mulch and reduction of insolation."

Just as a break in a wire of hair thickness in a sparking coil can immobilise a car, so absence of traces of minor elements can arrest the growth of a plant. Dr. Haworth is following Dr. Eden's work on nitrogen, phosphate and potash, by an investigation of minor element nutrition. All nutrients however, depend for their effect on the physical condition of the soil, which banks and holds them until the roots can absorb them, on water which conveys them, and on air which helps to convert them into the form in which they can be absorbed. Micro-organisms play an important part in all these processes and again their activity depends on organic matter and physical conditions. Although you may supply all or more than the requirements of nitrogen, phosphate and potash, they are useless to the bush unless the physical condition of the soil and the population of micro-organisms are able to make them available and supply them at the rate required by the bush.

The use of so-called organic manures is of little help because nitrogen has to be converted into nitrate and the bone meal to soluble phosphate before absorption can take place. Their contribution in the form of humus is negligible and does not justify their relatively very high costs. The cost of organic manure is high in terms of actual nutrients and the extra expenditure involved is far better devoted to green manuring.

5. **Various injurious factors.** Before I pass on to practical recommendations, I must warn you that soils in poor condition often liberate toxic amounts of minerals such as aluminium or encourage the development of parasites such as eelworms. We are particularly concerned about eelworms, and the only controls known to us at present are the predatory eelworms and parasitic fungi whose activities are encouraged by organic matter in the soil.

I hope I have advanced enough arguments to convince you of the vital necessity for maintaining the level of organic matter in our tea soils. In recent years we have rather tended to neglect green manures. Mr. Loos agrees with the rest of the staff that the only possible policy at present is to grow any green manures which will thrive, regardless of whether they are themselves hosts to eelworms. If *Tephrosia vogelii* will give you a good yield of organic matter, then grow it. When it becomes heavily infested and will not survive lopping, then grow the next best green manure. If you are fortunate and can grow Crotalarias equally well, by all means rotate crops of legumes but concentrate on growing as much organic matter as you can. Once there is a complete cover of tea, there is apparently little to worry about and, at the end of the first year of pruning, green manures should be crowded out. With the crowding out of green manures will go the crowding out of weed growth. Excessive weed growth is in many ways a measure of deterioration of cover. To my mind the most serious threat of blister blight is its effect on reducing cover and all efforts must be concentrated on keeping our soils covered and preventing the direct access of sun and heavy rain to them. The staff of the Tea Research Institute feel that every inch of spare ground of tea estates should be used for growing green manures of some description. In many cases uneconomic areas of tea could with advantage be used for growing grasses. If you wish to grow large quantities of grasses you must manure them heavily. We are laying down experiments on manuring both Gautemala and manna grass with a view to discovering the maximum economic responses. For the present a mixture of 6 parts sulphate of ammonia, 2 parts superphosphate, 1 part muriate of potash should be reasonably satisfactory.

The quantity to be applied depends of course on the rate of growth but when the grass is fully established and growing vigorously 2 cwt. per acre of

the given mixture should be applied about 10 days after each cut. These grasses should be allowed to grow at least 6 feet high before cutting.

The maximum benefit will be obtained where grasses can be thatched on to the soil, giving priority to areas where the tea is thin. Composting will help to reduce the eventual weight of materials to be carried to the field but wastes something approaching 70% of the potential humus forming material during the process of rotting. Nitrogen added to the compost will help to reduce this loss but, in all cases, the best results will be obtained by green manuring either with green stuffs grown *in situ* or green stuff carried on to the field. I must warn you, at this stage, not to attempt to grow grasses in the tea.

To sum up, therefore we recommend a maximum effort in producing green materials, the utilisation of road verges, ravines, unplanted patnas and even unproductive tea areas, in an all out effort to restore or maintain the organic matter in our soils, for the maintenance of organic matter means the maintenance of fertility.

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* DESMODIUM OVALIFOLIUM AS A COVER CROP FOR TEA.

By

T. M. Fernando.

(Enselwatte Group, Deniyaya).

(*Received 8th April, 1951*)

This article, though not wholly in accord in detail with the previous article on the maintenance of fertility in tea soils, is written in the same spirit. His Excellency the Governor-General addressing the Tea Research Institute Conference in December 1950 referred to the industry in terms of "Trustees" for a heritage of soil fertility which must be preserved by each succeeding generation.

The writer of this article asks what should be done to preserve cover after pruning when "the best cover crop for tea" is unable to function as a cover crop — a very pertinent question.

The mulch arising from the prunings of a heavy cover of tea should provide part of the answer. This leaf mulch is probably more useful on the surface for some time after pruning than it would be if forked into the ground. Green manures should also be used to give protection to soil exposed by pruning but spraying, as protection against blister blight during the very vulnerable period after pruning, complicates the growing of green manures. Ground cover, so long as it can be kept under control, would be in many ways more convenient than green manure. The views and criticisms invited by Mr. Fernando could be published in this journal.

With the kind permission of Messrs. The Panadura Tea & Rubber Co. Ltd., the Proprietors of Enselwatte Group, Deniyaya, I am able to state what has been done on this group to solve the question of soil erosion. Before pro-

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* *The Institute does not necessarily endorse the views expressed in papers contributed by persons other than members of the staff.*

ceeding further, I must record that this work would have not been possible were it not for the whole-hearted co-operation of the Company, and its Manager, Mr. L. C. de Mel.

The elevation of this group is approximately 1,500 feet arising to 3,500 feet. In 1946 a tea field, 18 acres in extent, was planted with Desmodium cuttings one foot apart on alternate rows after the field had been pruned. The age of this tea field at the time was five years. Incidentally, this is replanted tea in tea land that had been abandoned and allowed to grow into patna.

The cost of planting Desmodium was six labourers per acre. One year after planting Desmodium, there was a fair cover of it. Once the cover was well established weeding was done only round the bush. Fortunately, at this elevation, Desmodium has more creeping qualities than in the real low-country, but it is in no way a nuisance when weeding gets out of hand. It can be kept for two months without giving much trouble, *i.e.*, without its creeping on to the tea bushes and plucking surface. I do monthly weeding round the bush and the cost is only two or three labourers per acre. I have found that there is almost nothing to be cleaned in the silt pits in the drains after one year. While this fact reduces expenditure, it proves to what extent soil has been conserved. It may dispel the belief, which is rooted in some quarters, that only 25% of the rain water sinks into the soil and 75% drains off to rivers.

Comparative yield figures are given below of another field, which is of the same jat but which was planted a year earlier and has no cover, and the corresponding figures of the field that has the Desmodium cover. The planting distance of the tea in both these fields is 3— × 3—.

Year	23 acre field (Without Desmodium cover). Yield in lbs. made tea.	18 acre field (With Desmodium cover). Yield in lbs. made tea.
1944-45	76	—
1945-46	231	23
1946-47	246 (p)	200 (p)
1947-48	598	659
1948-49	547 (p)	589 (p)
1949-50	686	754
1950-51	712	831

(p) denotes pruning.

The increase in crop, I feel, is definitely due to the improvement to the soil and the conservation of it by the aid of a ground cover. One has really to see the improvement in the soil structure to realise how much can be done in a short space of time to improve the soil by a cover that suits the particular locality.

Provided I am given timely notice, I shall be very glad to conduct anyone interested in ground covers for tea around these blocks. After five years of experimenting, I am full convinced that there is nothing detrimental to the tea bush or tea crop by planting *Desmodium ovalifolium* in tea as a cover. I am planting the whole tea area of this group with it.

In conclusion, I would welcome views and criticisms of planting members of their experiences of Desmodium and other cover crops in tea. It would be of interest to learn of their successes or failures. I may, therefore, ask this question from members who believe that tea is the best cover for tea : How could soil be conserved after pruning and before the bush expands especially when pruning is done during one of the monsoons ? During such seasons, due to impact of rain on the soil, much erosion is bound to take place, as tea is a crop which can be successfully cultivated only in districts with a good rainfall.

* PLUCKING—THE CASE FOR LONGER ROUNDS IN UVA.

(Received 12th September, 1950)

The following note from the pen of an Uva planter is published in the hope that it will stimulate interest in an aspect of plucking which is too often lightly dismissed as of no agricultural significance except in relation to immediate crop returns. This tacit assumption is contested by the writer of this note, who is of the opinion that too short plucking rounds may result in bush deterioration. Whether he has proved his point or not the suggestion is one which merits consideration.

Weather obviously governs growth, and the differences in climatic conditions between those prevalent in Uva and in certain other parts of the Island are all too seldom allowed for when the length of plucking rounds comes in for criticism.

The importance to the bush of adequate foliage has been stressed in the Tea Research Institute article on page 66 of the *Planters' Association of Ceylon Review,* Vol. 17, No. 1.

If the bushes are plucked less often, the pluckers are likely to leave more below the level, which means a healthier bush, and, in the long run more crop.

In Uva, growth is slow in January and February owing to the cold and, therefore, in spite of blister blight, quick rounds are unnecessary.

From March to June growth is certainly more rapid, but it is important that the foliage lost during the very severe attack of blister blight (which occurs from December to February) should be made good throughout the depth and breadth of the bush ; and this is obviously more easily accomplished by allowing a longer interval of rest between rounds.

From July to September, owing to the usual Uva drought, there is very little growth, and therefore short rounds are both unnecessary and costly.

In October and November long rounds give the bushes a chance to replace the foliage lost, or never made, during the preceding drought (May or June to September).

In December, which is a cold, misty month, growth is very slow, and therefore, in spite of blister blight quick rounds are still unnecessary.

Clearly no rule can be laid down for length of rounds, though 11 — 13 days generally seems about right, going up to as much as 18 days after drought, blister blight, sunless or cold weather. Only the superintendent is in a position to decide, taking into consideration, as he can, the situation of his estate, the varying climatic conditions and the availability of labour. Finally, the quality of the made tea has been proved to be not adversely affected by longer rounds.

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* *The Institute does not necessarily endorse the views expressed in papers contributed by persons other than members of the staff.*

STUDIES IN BLISTER BLIGHT CONTROL.

VI. AN EVALUATION OF SOME COMMERCIALLY AVAILABLE FUNGICIDES FOR THE CONTROL OF BLISTER BLIGHT.

By

J. W. Pfaeltzer.

(Koninklijke/Shell-Laboratorium, Amsterdam).

(*Received 15th September, 1950*).

A relatively small research institute in a corner of the world remote from the main centres of fundamental scientific research is at a grave disadvantage when new concepts of a subject such as crop protection are called for.

Although the application and adaptation of low volume spraying with copper fungicides has met with a highly satisfactory degree of success, especially in view of the difficulties of terrain and weather, the control of blister disease of Ceylon tea demands attention to new approaches to the general problem of the control of fungus disease of plants.

When Koninklijke/Shell Laboratorium offered their co-operation and agreed to send Dr. J. W. Pfaeltzer to work at the Tea Research Institute, the powerful resources of the Shell Laboratories in Amsterdam became linked to our small spearhead in the field.

During the S.W. monsoon of 1950, Dr. Pfaeltzer carried out a very extensive and accurate series of trials with 188 formulations of 58 different fungicides. The experimental area comprised 296 units including the controls.

The brief account which follows concludes with the statement "investigations in progress shew that a number of experimental materials have given a control equal to that of Perenox or Shell Copper but at a lower dosage of active ingredient per acre."

Fundamental research of this nature is not usually spectacular. In the future — how far in the future cannot be estimated — this "lower dosage of active ingredients" may develop into a real advantage in the science of crop protection. Dr. Pfaeltzer has returned to Ceylon to continue this investigation in the south west monsoon period of 1951 and the Tea Industry of Ceylon is greatly indebted to the Shell Company for their invaluable contribution to the more fundamental aspects of research on blister blight control.

Since a large number of fungicides are now commercially available, it is important to evaluate their effectiveness for the control of blister blight. The present report places on record the results of a large scale statistically randomized trial carried out at the Tea Research Institute of Ceylon as part of a much larger co-operative project, which aims at developing economic methods of blister

blight control on tea which is in pluck ; but for obvious reasons these tests have been confined to tea which is recovering from pruning. While the list of fungicides included in this test is by no means complete it does include the more generally available products and in any case includes at least one representative of the several "types" or "groups" of product. Furthermore, the trial was set up at relatively short notice. The non-inclusion of any product should not be regarded, therefore, in any way as a prior judgment on its merits for the control of blister blight.

The trials were made on a specially selected plot at St. Coombs, where severe blister blight had occurred for the last two years and where unsprayed tea bushes failed to form new leaves owing to the extreme severity of the attack. Units of 20 bushes per treatment were adopted and these were completely separated from each other by at least one bush or guard row. The bushes constituting the units to be treated were given the normal pruning on the 9th and 10th of May, 1950, which was about 10 days before the monsoon rains started. All other bushes and guard rows were unpruned.

The unpruned bushes and guard rows provided a uniform source of infection over the whole area. At two weeks after the start of the monsoon more than 50% of the new shoots of these bushes were infected and one week later over 90% were infected, which resulted in a complete inhibition of new leaf growth. It must be concluded therefore that the trials were made under almost ideal conditions and that the infection potential was uniform over the whole area.

Spraying, which was done by means of hand sprayers employing two standard types of nozzle*, was started one month after pruning, at which time 90% of the buds on the pruned bushes were breaking. Sprayings were repeated at weekly intervals.

All materials were applied at the amounts generally recommended by the makers, but the amount of liquid used was invariably 120 litres per hectare (approximately 10 Imperial gallons per acre).

The standard against which all materials were compared consisted of three units which always occurred together, *viz.* —

(1) Unsprayed.

(2) Sprayed with Perenox.

(3) Sprayed with Shell Copper Fungicide.

Fifteen of these composite units were scattered over the entire area. Shell Copper and Perenox were used at a concentration of 0.2%, *i.e.*, about 4 ozs. in 10 gallons of water per acre per application. Although there was obviously only a slight variation in intensity of infection on the unpruned bushes, each treatment was compared with its nearest "control block."

Visual examination of the plots was made after the 4th, 5th, 6th and 7th sprayings, separate attention being paid to the following :—

(a) Infection of the leaf.

(b) Infection of the stems.

(c) Die-back of the young shoots.

(d) Amount of defoliation.

Each of these phenomena was assessed upon a previously agreed degree of attack expressed on a numerical basis.

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* *Shell/Delft (Luynet nozzle) and "T jet" nozzle.*

This evaluation was carried out independently by four observers, all of them experienced investigators. A final comparison of their results showed a completely satisfactory agreement.

The following conclusions can be stated:—

I. Materials, the control by which was not so good as that given Perenox and Shell copper fungicide.

(a) Elemental sulphur, *e.g.*:—
wettable sulphur "Thiovit" Sandoz.

(b) Thiuram disulphides and dithiocarbamates, *e.g.*:—
tetramethyl thiuram disulphide: "T.M.T.D." Plant Protection,
ferric dimethyl dithiocarbamate: "Ferbam" Du Pont de Nemours,
zinc dimethyl dithiocarbamate: "Ziram" Du Pont de Nemours,
zinc ethylene bis dithiocarbamate (1,000 gms. per ha.=0.9 lbs./acre and less): "Zineb" Du Pont de Nemours and "Dithane Z-78" Rohm & Haas,
sodium ethylene his dithiocarbamate: "Dithane D-14" Rohm & Haas

(c) Polysulphides, *e.g.*:——
polyethylene polysulphide: "Good-rite P.E.P.S." Goodrich.

(d) Calcium thioglycolate — Robinson Bros.

(e) Glyoxalidines, *e.g.*:—A mixture of:—
2-heptadecyl glyoxalidine
2-pentadecyl glyoxalidine
heptadecenyl glyoxalidine
1-hydroxyethyl — 2-heptadecyl glyoxalidine:
"Craig 341B" "Craig 341C" — Carbon and Carbide Cy.

(f) 2, 4-dinitro-6-caprylphenylcrotonate: "Arathane CR1639" Rohm & Haas.

(g) Salicylanilide: "Shirlan" Plant Protection.

(h) Calcium 8-hydroxyquinolinate: "Carpinol" La Quinoleine.

(i) Chlorinated calcium 8-hydroxyquinolinate: "Carpinol C" La Quinoleine.

(j) 2, 3-dichloronaphthoquinone: "Phygon" U.S. Rubber Co.

(k) Tetrachloroparabenzoquinone: "Spergon" U.S. Rubber Co.

(l) N-trichloromethylthiotetrahydrophtalimide: "SR 406" Standard Oil.

(m) Copper oxychloride: "Blitox", Pest Control Ltd.*

(n) "Fungicide 5379" Carbon and Carbide Cy, of unknown composition

II. Materials which gave a control of the same order as given Perenox and Shell copper fungicide.

(a) Several copper compounds, *e.g.*:—

Bordeaux mixture (1:1:100) in kg. and litres=about (5:5:50) in lbs. and Imp. gall.

Cuprous oxide: "Yellow cuprocide" Rohm & Haas. "Copper Sandoz" — Sandoz.

Copper oxychloride: "Coppesan" — Boots. "Cuprokylt" — Universal Crop Protection.

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* *This early sample was from a defective batch. Manufacturers of "Blitox" has since been improved and standardized and the present product is fully the equal of the other copper fungicides referred to in this report.* (*Ed.*)

Copper hydroxyquinoline : "Bioquin" — Monsanto.

Copper oxychloride and copper-8-hydroxyquinoline mixture : "Vitosan" — Vitax Fertilisers.

(b) Probably polysulphides, e.g. :—

Calciumpolysulphide "Sulfonette"; Copper Mc Dougall & Robertson.

(c) Zinc ethylene bis ithiocarbamate (2000 gr./ha. = 1.2 lbs./acre and more). "Dithane Z-78" — Rohm & Haas.

All copper containing products were diluted up to a copper content of the spraying liquid equal to the standard. With the non-copper containing products the concentration recommended by the manufacturers was used.

While the present report is confined to an evaluation of products which are commercially available, investigations in progress show that a number of experimental materials have given a control equal to that of Perenox or Shell Copper but at a lower dosage of active ingredient per acre.

CROP PROTECTION COURSES 1951.

Three day courses on crop protection were given at Radella, Darrawella, annd Uva Gymkhana Clubs, and the Board Room in Peradeniya Gardens between April 17th and May 10th, 1951. Well over 400 Superintendents attended these courses and representatives of Colombo Agency Houses were also present at the lectures on the first day of the Peradeniya course.

The instruction provided was primarily of a practical nature but the technical principles involved in crop protection were explained in a limited number of lectures. These lectures are reproduced by general request.

I. INTRODUCTORY LECTURE

By

J. Lamb.

A few words of explanation about the objects of, and the arrangements for, these crop protection courses are first necessary. Last year we arranged a course of instruction in spraying for superintendents taking part in our extensive experiments and since this course was generally agreed to be worth while, we offered to repeat it this year for the benefit of those estates commencing spraying in 1951. This offer was made at the conference held last December and superintendents and others interested in the details of crop protection methods for the control of blister blight were asked to register their names for special blister blight circulars. All the preliminary arrangements for these courses were tharefore made through the blister blight circulars. Since a number of superintendents who wished to attend the crop protection courses had not registered their names for the blister blight circulars, some misunderstanding has subsequently arisen, and I have requested the Planters' Association to draw attention in one of their general publications to the availability of these circulars to anyone wishing to register their names.

Owing to the very large response for accommodation in these courses we had to decentralise and run four courses instead of one. Four weeks instead of one week have therefore been taken up in giving instruction on crop protection methods, and as a result, our advisory work has been largely suspended and much

of our correspondence delayed. Preoccupation with these courses has also had the effect of delaying our south west monsoon experiments but we feel that, since spraying is evidently going to be practised on a very wide scale this year, we should do everything possible to ensure that it is successful.

Opinions have also been expressed to the effect that three days is rather too long for a course of this description but our experience has proved otherwise and, in any case, we would rather be criticised for allowing too much time, than be accused of rushing instruction and causing confusion. Since it is necessary that a course of this nature should be complete and self-contained, there will be some repetition of our published advice but since some of you may not have been present at the conference last December or may not have studied the *Tea Quarterly* very closely, there is very little which could safely be omitted even if we attempted to shorten the course. I particularly ask you to beware of underestimating the importance of detail. Little things like over-tightening a gland in a spraying machine especially designed to tighten with the pressure of spray fluid may cause endless trouble and waste of time in the field. Success with crop protection methods is essentially a result of attention to detail, and if you have not had any experience of spraying, I feel sure that you will eventually be thankful for some of the advice given during this course, elementary though it may seem at the time.

I now wish to deal with a number of diverse subjects, all bearing on the general policy with regard to crop protection. Firstly, I think I have some explanation of the mystery about the total exports of tea since blister blight arrived. At the conference Mr. G. K. Newton suggested that increased use of fertilisers might provide some explanation of sustained yields, in spite of evidence of severe damage in the south west monsoon districts. I find that since 1946 the consumption of ammonium sulphate has increased from 30,000 tons up to 54,000 tons in 1949. I have reason to believe that this consumption may rise to as much as 65,000 tons during the period July 1951/June 1952. I will now show you a table (Table 1) of figures extracted from the Commonwealth Economic Committee's Thirty Fourth Report on the Trade in Fertilisers :—

Table 1. *Imports of Fertilisers into Ceylon*
(*Thousand tons*).

Description	1938	1946	1948	1949
Nitrogenous materials.				
Ammonium sulphate	35	30	47	54
Sodium nitrate	1	—	4	4
Cyanamide	1	—	1	—
Refuse of salt petre	1	—	—	—
Total...	38	30	52	58
Phosphatic materials.				
Rock phosphate	11	18	22	25
Superphosphate	2	1	—	1
Basic slag	1	—	—	—
Total...	14	19	22	26
Potassic materials.				
Muriate of potash	6	7	6	13
Sulphate of potash	—	—	1	—
Kainite } Sylvinite } ...	1	—	—	—
Total...	7	7	7	13
Total chemical fertilisers	59	56	81	97
Organic materials (all kinds)	32	30	30	18

Photo by R. C. Scott.

PLATE I.

Spraying of tea in bearing. General view of demonstration given on Darrawella Estate, Dickoya.

There you will see the very large increase in nitrogen and also the big increase in the consumption of potash fertilisers presumably arising from Mr. Portsmouth's advice in connection with potash deficiency. I think there is no doubt whatsoever that blister blight has caused loss of crop, but that the increased use of fertilisers has enabled us to maintain the amount of tea exported.

Had it not been for blister blight, I fully believe that there could have been 15 or 20%, perhaps even 30% increase in Ceylon's tea crop. Although I think there is no doubt about direct loss of crop I should point out that we, at the Tea Research Institute, are most concerned about the loss of the third leaf which is normally left for the bush. For this reason, I coined the description of the blister blight campaign given at the conference — the battle for the third leaf. In assessing the damage caused by blister blight, I think it is essential to distinguish clearly between direct loss of flush and loss of crop through a steadily deteriorating condition of the bushes.

Our Loss of Crop Experiment in providing information about sources of loss. Before blister blight attacks started last year, the yields from the protected and unprotected areas were almost identical. Severe attacks of blister blight in the early stages no doubt caused an actual loss of flush through bud damage and through stem attack. There is now, however, ample evidence that the loss of the third leaf has lowered the yield potential of the unprotected area. I will now show you a slide (Table 2) giving the total yields to-date from which you will see that the fully protected plot has given 994 lbs. per acre against 669 lbs. from the unprotected. The made tea weights of the last two or three months show that the difference in the condition of the bushes in the protected and unprotected areas is now having its effect. Both, the area sprayed right through the south west and north east monsoons and the area sprayed during the south west monsoon only, gave some 270 lbs. made tea each between the 5th February and 11th April. The figures are remarkably even — one was actually 277 lbs. and the other 270 lbs. The unprotected area in the same period gave only 203 lbs. per acre and a visit to the area will rapidly convince anyone that this is due to actual deterioration of the unprotected bushes. You will note that full protection involved 37 sprayings costing a total of Rs. 96/-, whereas protection during the worst of the blister blight attacks involved only 16 sprayings at a cost of Rs. 42/-.

Table 2. *No. 8 Field Crop Protection Experiment.*
Pounds made tea per acre.

Time Period	Unprotected	Protected	
		Both monsoons	S. W. monsoon only
	A	B	C
10th May 1950 to 10th May 1951	669	994	909

Plot B — sprayed 37 times Rs. 96/-.

Plot C — sprayed 16 times Rs. 42/-.

Where blister blight is causing deterioration, I think that spraying is essential to arrest the decline. In all areas where attacks of the blight persist for any considerable period I think that spraying is well worth while. Where, however, attacks are of short duration I have doubts about the economics of spraying. We propose to carry out experiments in the north east monsoon zone this year in order to obtain more information on this subject.

Supplies of equipment and fungicides have given rise to considerable anxiety but, so far as I am aware at present, most of our requirements will be obtained. Apart from assisting with supplies of copper sheets the Imperial Chemical Industries have developed a protective lacquer which will make it possible to fabricate knapsacks from steel sheet and this will afford considerable help to some manufacturers of spraying equipment.

The fungicide position is also much better than we anticipated although it is still very obscure. At this moment I cannot tell you whether the materials from which fungicides are manufactured, namely copper turnings, are actually controlled. We have however made an application to the Ministry of Supply in the U.K. for an allocation of 200 tons of copper metal. After a long delay, this came back to us with the information that it was a gross overestimate because Ceylon only consumed so many hundredweights of copper fungicides in 1950. I replied as quickly as possible pointing out that large scale spraying would not commence until 1951 and that we are only adopting crop protection measures from May/June this year. I was astonished at the amount of copper fungicide which was used last year and it clearly indicates that a number of estates were spraying on quite a considerable scale long before we had been given a temporary tolerance figure to work on. In support of our application for release of copper metal, I was also able to point out that the U.K. Ministry of Food had allowed us a definite tolerance figure and that this would enable the widespread adoption of spraying with copper fungicides

Sources of copper fungicides on the continent and also in America are being tapped and we have examined a number of samples of hitherto unheard of proprietary preparations which appear to be quite good. I must, however, give you this warning that we have reduced our preliminary examinations to a mere laboratory inspection to give information about the state of division and the formulation. Although we could probably spot the materials which are likely to cause taints we cannot be absolutely certain that these new preparations are quite free of any liability to cause taints. At the present moment Perenox and Blitox are the only two formulations of which we have any considerable experience. We have sufficient experience of Cuprokylt and Copper Sandoz to say that they are free of liability to taint and that they are both preparations of a very high standard. Any other proprietary fungicides should be used with caution until it is well established that they are free of any liability to cause taints when sprayed on tea in bearing.,

At the present moment we advise that all the available fungicides should be used at a concentration of four ounces in ten gallons of spray fluid. We are carrying out trials with lower concentrations but I should warn you that the percentage of copper in a fungicide formulation is not the only criterion of its efficiency. Very finely ground preparations may stand up to considerable dilution but coarser preparations with the same content of copper will fail to give sufficient protection when used below the recommended strength.

When manufacture involves operations such as grinding, a great deal also depends on standardisation by the manufacturers. The cost of fungicides is still only a small part of the total cost of protection and no risks should be taken through "cheese paring" economies. Where spray protection is to be given to tea pruned in the south west monsoon the tremendous loss involved in failure of protection demands strict adherence to the concentration we recommend.

Our trials with lower concentrations of different formulations will take some time to complete, and will be published as they become available. We must rely on all manufacturers giving a specification for the range of particle sizes in their products and in a guarantee that they will maintain the standard set by their specification.

Although I gave a completely impartial opinion of the relative merits of wet spraying and dusting at the last conference, there does seem to be an impression that the T.R.I. is "anti-dusting". This of course is quite ridiculous for why should the T.R.I be "anti-anything" which can help control blister blight? Nobody could be more delighted than I should be to see dusting a complete success, but experiments during the north east monsoon have given rise to certain doubts about the efficiency of dust, particularly that containing 2% of copper.

Quite apart from the actual efficiency of dusts, there is the question of costs and the cost of dust has risen to such an extent that it will involve expenditure of at least Rs. 4/- per acre per ten day round for dust only, without any allowance for the cost of application.

It also appears desirable to dust at intervals more frequent than ten days and this will further increase the cost of application.

Dusting is therefore still in the experimental stage and we cannot recommend it for routine use at present and have not included any practical instruction on this method of protection in our course.

Since dusting is a very attractive approach to the problems presented by steep and inaccessible areas we intend to pursue our experiments to a logical conclusion, even though economic and supply difficulties may preclude its immediate adoption in practice.

As a matter of interest we have a large scale experiment planned for this this year which we are carrying out in co-operation with Messrs. Harrisons & Crosfield on Dessford Group. There, we shall be trying 2%, 4% and 6% concentrations of copper over a considerable area. We also have some ten other formulations of dusts, both of copper oxychloride and cuprous oxide, which we shall be testing on a smaller scale on Mattakelle estate.

Many estates and agencies seem to be hesitant to obtain their full requirements of knapsack spraying equipment because of the possibility of their being superseded in the near future. Knapsack spraying is very far from being the perfect method of protection against blister blight but it does provide a substantial contribution to the solution of our difficulties and is of immediate practical application.

Where blister blight has caused severe loss of crop — or potential crop where increased fertiliser applications have only maintained crop — with or without deterioration in the condition of the bushes, I strongly recommend the adoption of wet spraying. The fear of equipment being superseded will always be present while there is progress in scientific research but my opinion is that there is nothing at present to justify this excuse for failure to make a start with the adoption of crop protection measures.

I stress the point however that there should be substantial evidence that blister blight is causing damage, for crop protection is not a measure to be undertaken lightly.

I must also warn you against false hopes that this problem child will ever be delivered by "twilight sleep". The chances are that you will have to be delivered of it the hard way. I can see no prospect of, say, a pinch of some wonderful new discovery being added to fertiliser mixtures for the purpose of controlling plant disease. With all the apologies due from a realist I must also express the view that blister blight has come to Ceylon to stay.

Having given you the cold and hard facts of the situation as I see it, I do not wish to leave you with the impression that I am pessimistic about the chances of advances on knapsack spraying and dusting.

The greatest advance which can possibly be made at the present moment is the development of fungicides which remain effective for a period of time longer than the present ten days. Even if a partially systemic material can be developed which will give protection for twenty days, it would halve the present cost of protection. All such developments will almost certainly require wet spraying applications to begin with, as the application of new fungicides in the form of dusts is generally a secondary development. Dr. Pfaeltzer is returning to Ceylon shortly, to continue the development of new materials which gave promising results in the screening trials last year.

Again, I do not wish to give the impression that we are satisfied with what has been done so far on application. I must tell you we are pushing ahead with large scale mistblowing experiments. All this work is highly technical and does not concern us in this particular course of instruction.

On the subject of costs, a subject which will particularly interest Agency House representatives present today, I must point out that although we have published figures supplied from Ragalla and Downside estates in the blister blight circulars, these will not apply to cases where the terrain is more difficult or to estates with less facilities in the form of roads and paths.

Our Kataboola experiments were designed to cover a range of conditions which were fairly representative of normal extremes. Figures given at the conference and later published in the *Tea Quarterly* showed that costs for the same routine varied from Rs. 1.91 per acre to Rs. 2.66 per acre and variations between different estates will be at least equally wide.

Where high costs are in any measure due to lack of roads and paths the prognosis for the disease and our hopes of future progress in mechanical application of fungicides justify a policy of road and path improvement.

Several superintendents have, during these courses, expressed fears about their costs owing to the fact that they have been provided with unsuitable spraying equipment. I can only justify their apprehension by quoting figures obtained by Mr. A. R. Williams on Ragalla, who found that, with unsuitable equipment, 13 labourers were required to spray 120 acres whereas, with the equipment we recommend, 16 labourers were able to spray 480 acres in the same time.

We have issued repeated warnings about the danger of unsuitable equipment and, where our advice has been disregarded, we cannot offer any solution except replacement of unsuitable equipment.

Although this course of instruction will be very largely concerned with wet spraying technique, I wish to preserve a sense of proportion by referring to the importance of agricultural methods of control. For instance, we wish to make it quite clear that we do not advocate the automatic reversion to south west monsoon pruning because protection with wet spraying is possible. As I said, in a recent article in the *Planters' Association Review*, wet spraying is a form of assistance and not a new religion — it is a servant and not a master. You must use wet spraying to help you and to serve the best interests of the estate. It will certainly enable you to lengthen your present pruning period and to avoid the exposure of harder pruned bushes to hot sun immediately after pruning.

The lighter methods of pruning advised by the T R.I. are becoming generally adopted and are giving good results. One of the features of lighter pruning is a quick recovery but a rather heavier prune may occasionally be necessary. In this case, we suggest that you prune these fields at such a time that bare wood is not exposed to hot sun and, if this involves difficulties with blister blight, then employ spray protection.

We cannot give any hard and fast pruning instructions or dates any more than a farmer can be told when to plough, sow or reap. Each district and each estate must make its own decision but spray protection will help to correct any difficulties which arise from our previous advice to prune into fine weather.

Generally speaking, spray protection should be devoted to the establishment of a good cover of maintenance foliage. Much can be done before tipping and a delayed and higher tip gives the bushes a good start. Spray protection is invaluable at this stage of recovery from pruning and, in unexpected periods of bad weather, may be used as an emergency measure for giving every possible chance to the bushes before they are brought into bearing. Again, first year fields should be given priority, partly because they are the more vigorous and the potentially highest yielders, partly because they contain more susceptible material, but mainly to ensure the development of a complete cover of maintenance foliage. Once bushes have a good cover of old leaf and are meeting in the rows, blister blight cannot cause any serious deterioration.

Finally, I wish to say a little about the Kataboola Loss of Crop Experiment because I think this approach to blister blight control is a very promising one and may well be used to supplement protection by spraying, especially until equipment and materials are freely available. The next slide (Table 3) shows you the up-to-date figures from this experiment.

Table 3. *Kataboola Loss of Crop Experiment. Crop Returns from 24th July to 14th May, 1951.*

Plot No.	Description	Yield in lbs. made tea per acre	Increase in lbs. made tea per acre
1	Unprotected, normal pluck	643	—
2	Protected weekly, normal pluck	735	92
3	Protected every 10 days, normal pluck	697	54
4	Unprotected, fish leaf pluck	705	62

Note. No. 4 was rested with spray protection from 21st November, 1950 to 24th December, 1950.

You will see that weekly spray protection has given the highest yields and that, although the fish leaf plucked plot has given a higher yield than the control, it is lagging behind compared with the figures given at the conference. The next slide (Table 4) shows how the rest and delayed tipping has set this yield back between December and February.

Table 4. *Kataboola Loss of Crop Experiment. Result of delayed tipping of fish leaf plucked area. Crop return between 24th December, 1950 and 12th February, 1951.*

	Pounds made tea per acre
No. 2 Normal pluck, protected weekly	120
No. 4 Fish leaf pluck	23

The next slide (Table 5) shows a further analysis of this plot and that 525 pounds of leaf were lost as coarse leaf and tippings :—

Table 5. *Kataboola Loss of Crop Experiment.*
No. 4 plot — Fish leaf plucked — Green leaf weights (per acre) at tipping after 33 days resting.

200 lbs.	for manufacture
525 ,,	coarse leaf
725 ,,	total removals
72%	coarse leaf discarded

It is quite evident that we have not found the best way to deal with the bushes after the resting period and this is one of the objects of the experiment. In spite of the long period of hard plucking, the bushes are now, as a result of the rest under spray protection, in excellent condition and I think there is little doubt that the yield will increase very rapidly in the next few months.

The whole point of this experiment is that a high degree of "prevention" was attained by removal of susceptible material. This has not only given an increased yield but has also reduced the potential infection arising from the blisters which would otherwise have developed on that area. We are now convinced that the resting period was too long and think that resting should have been so arranged that shoots which formed three leaves and a bud after resting should have been plucked back to two leaves without discarding any new growth. We are now incorporating the results of this experiment in a large experiment on St. Coombs and hope to develop a method of agricultural control whereby the amount of spraying necessary is minimised to the period of three weeks before resting commences and another three weeks or so during the actual resting period, so that a total of only six weeks spray protection during the course of the south west monsoon will be necessary.

I do wish to stress the importance of the reduction of the amount of potential infection in all these treatments where the development of blisters is prevented. Serious infection is intensely local and success does undoubtedly breed success. You may well ask "Why the degree of increase in crop is so low on Kataboola compared with the Loss of Crop Experiment on St. Coombs". The answer to this is undoubtedly the very severe degree of infection in the area of the Kataboola Loss of Crop Experiment, and large scale protection on such an area may eventually give more dramatic results than it is at present giving on St Coombs.

There is therefore no easy method of protecting tea from blister blight and crop protection will involve much extra work and difficulty. There are, however, highly effective methods available and I can assure you it will become progressively easier as the protected areas increase in extent.

II. THE CAUSATIVE FUNGUS

by

C. A. Loos.

My task today is to explain, in as non-technical a language as possible, the complete life-history and functions of the organism which causes the blister blight disease of tea, as we fully realise that, without this basic knowledge, very little can be achieved in the form of disease control.

As most of you are aware, the causative organism of the blister blight disease is a fungus. Now what is a fungus and what is its relationship to plant life? Even among scientists, the answers to these questions are diverse, as there is a difference of opinion as to whether some of the lower forms of plant life should be included amongst the fungi. In this connection, it is well to quote from one of the latest publications, *Plant Pathology* by Sir Edwin Butler and Dr. S. G. Jones. "The chief characteristic of the fungi is the absence of chlorophyll, even in those members which happen to be coloured green (the colour associated with chlorophyll). This carries with it a profound difference in mode of life from other plants, for they (the fungi) take their food in the form of organic matter, whereas the chlorophyllous plants (as for example the tea bush) obtain their carbonaceous food from the carbon dioxide of the air, through the energy of sun light."

In other words, the fungi in the absence of chlorophyll, which is necessary for food manufacture, must have their food already prepared for them in a form suitable for immediate digestion. Photosynthesis, which Mr. Portsmouth will deal with in his address, therefore, does not take place in the fungi.

The fungi can be classed in two distinct groups — saprophytes and parasites. Saprophytes feed only on dead matter while parasites get some or all their food from living bodies. The parasites may be still further divided into two groups — facultative parasites an example of which is *Poria hypolateritia* — a common root disease fungus of tea — can exist on either living or dead tissues. It is possible to grow the fungus under sterile conditions in a test tube of culture medium. The fungus (*Exobasidium vexans*), which causes blister blight of tea, is on the other hand an obligate parasite which is unable to live on dead material. It cannot be grown on culture media but requires a living tea leaf for growth. The fungus does not kill the part it enters, death follows in due course but not until the fungus has completed its life cycle and reproduced its kind. Now with this basic knowledge of what a fungus is and how different forms operate, we can pass on to the disease, blister blight itself.

All of you are familiar with the appearance of the fruiting body of blister blight. In fact, your presence here today is because you have seen too much of it and would rather have the effects of the disease under control.

The characteristic white blister which forms on the undersurface of the leaf, and on the young tea stems is composed of numerous white fungal strands or hyphae, at the apex of which spores or fruits of the fungus are produced. To the unaided eye the velvet-like white mass appears uniform but under fairly high magnifications you will see that in reality it consists of numerous individual compact bundles situated close together like the pile of a carpet. The white blister is the hymenium or fruiting layer of the fungus. It is the only part of a blister colony visible to the unaided eye.

For further study, at high magnifications, a transverse section of a blister is necessary. Even then it requires a trained eye to distinguish and differentiate between the structures that made up the blister colony. For your convenience, special diagrams have been prepared and I am using these as an aid to demonstration.

The first diagram (Fig. 2) shows a transverse section of part of a tea leaf. The section passes through a mature, sporing blister. For the moment, we will confine ourselves to the fruiting stage of the fungus itself.

As stated previously what you now see is a highly magnified version, and of course diagramatic.

The fertile mycelial strands of fungus or hyphae (termed basidia) on which the spores are borne are at first clavate or club-shaped. The basidia possess two nuclei which pass into the young spore when the basidium or the fertile hypha is mature. The basidium gradually widens out near the apex and forms two, or rarely three, spiked projections or sterigmata at the apex of which the spores or seeds of the fungus are borne. In a section of a white blister, spores in different stages of maturity may be seen, the very small unicellular spores being the immature ones which are very firmly attached to the basidium and fairly difficult to dislodge. When ripe the spores become two-celled following the formation of a septum or wall which divides the spore into two almost equal parts. At this stage the blister is ready to discharge its ripened spores. In the case of blister blight, as with most other *Basidiomycetes* with the hymenium or fruiting bodies borne externally, the spores are discharged from the basidia with some considerable violence. The distance to which the spores are discharged or shot away is sufficient for them to clear the hymenial surface and pass into air currents. Spores dropping from members of a related family, the mush-rooms and certain bracket fungi which are common objects on decaying tree stumps, may be seen, without the aid of a microscope if a beam of light is concentrated on them. The spores appear as shining, dancing objects similar to the shimmering effects produced by dust particles in a sun beam. These fully grown spores are of microscopic size, measuring 0.006 — 0.014 mm. long by 0.0028 × 0.004 mm. wide.

As long as an infected leaf remains attached to the bush and the fungus is alive there is a continuous discharge of spores from the basidial layer but, if the leaf is plucked, discharge soon ceases unless the cut shoot is supplied with water. Spore discharge is regulated by the pressure of the cell sap upon the wall of the basidium. The spores may be collected by placing a clean glass slide a short distance below the hymenial surface, and covering the whole shoot or young plant with a large jar. The jar is used to cover the shoot in order to eliminate air currents, which would carry the very light spores away from the glass slide. In a few hours a white deposit settles on the surface of the glass slide, which, when placed under the microscope, shows the deposit to be made up of large numbers of blister blight spores. A very rough estimate of the number of spores can be obtained from measurements of the area covered. That this number probably exceeds a million can only be imagined if it is realised that 10,000 spores can lie side by side without over-lapping on an area one millimetre square. From this may be gauged the potential output of spores from a single blister which may fruit, under suitable conditions, for a week. The number freed from blisters formed over an acre of unprotected tea must then be truly gigantic.

Round the spore, completely enveloping it, is a thin sheath of mucilage. The adhesive property of this sheath is of considerable importance as the spores remain fixed and cannot be dislodged even if the slide is placed in running water, as from a tap. The spores stick equally well on other surfaces such as leaves, cellophane or plastics. Even in heavy rain they remain fixed

firmly to leaves and hold their position until conditions are favourable for germination. Large numbers of course find lodgment on unsuitable bodies and only a very minute percentage of spores can ever reach tissues in which they can develop. For survival of the species gigantic numbers are therefore necessary.

The spores are colourless or hyaline. They are so light that in absolutely still air they fall very slowly and even the very small movement caused by convection currents, set up around a leaf, may carry them away. Sometime ago, in an effort to find out the distance spores are forcibly discharged, it became clearly evident how easily they are carried even in imperceptible air currents, to long distances. An infected seedling was placed at one end of a box, which could be tightly closed, and slides were placed on the floor of the box at varying intervals. The next day spores were found on the slides 30 inches away from the diseased plant. This forcible discharge prevents the spores from massing together or sticking to the hymenial layer, and is nature's method of dispersal.

The rate of fall of spores was watched by a scientist about half a century ago. He used a horizontal microscope and a revolving drum to record accurately the rate of fall. Relatively small spores fell at an average rate of 0·37 mm. per second. A spore takes about one hour to fall 4½ feet in still air.

Blister blight spores begin to grow or germinate under certain conditions only. A thin film of water is more favourable for germination than a drop, whilst ideal conditions are obtained when water vapour condenses as dew around the spore. This is one of the chief reasons why the disease is most prevalent in areas liable to mist and in hollows where dew forms early and persists for a fairly long period in the mornings.

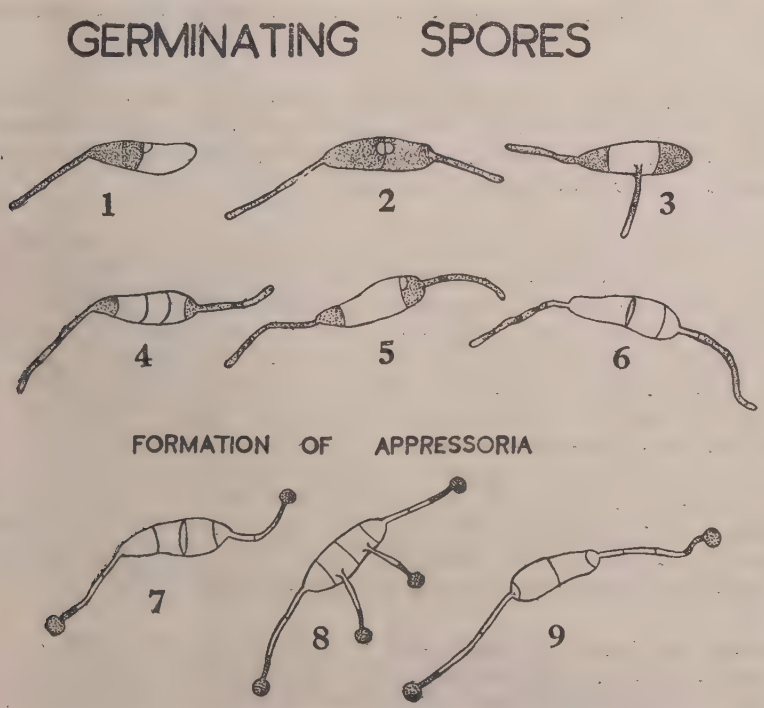

Fig. 1. 1—6. *Germinating spores before the formation of appressoria. Note movement of protoplasm into germ tubes.*
7—9. *Formation of appressoria. Spores empty of protoplasm.*

If the slide on which the spores have been deposited is wet with a fine mist, germination will commence in a few hours. (Fig. 1). The first indication of germination is the emergence of a tube from one or both ends of the spore; occasionally 4 or 5 germ tubes may emerge from one spore. Germination may commence two hours after wetting. Two to three hours later a spherical body, the appressorium, is formed at the extremity of each germ tube.

At this point it is necessary to digress.

Infection with different fungi on tea leaves can be by one or two means, via the stomata, the breathing cells on the under surface of the leaf, or by mechanical penetration through the leaf cuticle. Germ tubes which enter through the stomata do not normally form appressoria, which are common in fungi where penetration is through the leaf cuticle. The formation of appressoria at the ends of germ tubes of a germinated blister blight spore therefore suggested that entry into the leaf was by mechanical means. It may interest you to know that even though blister blight was studied for over half a century, we were the first to observe this method of penetration. The observation, which was the result of careful study, completely altered the method of spray application.

In the diagrams I have prepared for you entry is shown through the upper surface of the leaf. We have found that, contrary to the old assertions, entry is mainly from the upper surface; although it is possible for entry of the infection tube to be through the lower surface as well, this method of entry is fairly rare.

Before explaining the growth of the fungus in the leaf tissue it is essential that you should now become acquainted with the internal structure of a leaf, as the eventual emergence of the fruiting bodies of the blister fungus depends to a large extent on this structure.

On the upper surface of the leaf (Fig. 3) is a continuous unbroken cuticle which covers the upper epidermal layer of cells. A similar layer of epidermal cells is present on the lower surface as well, but in this case the cuticle is not continuous but broken at irregular intervals by the formation of stomata or breathing pores through which the exchange of gases takes place. The cuticle, as its name implies is a toughened skin with the chief function of restricting transpiration mainly to the stomata. Most young organs, leaves and stems, before they have attained their full size, possess a very thin cuticle and exhibit considerable cuticular transpiration, hence the necessity of large numbers of leaf hairs on the young leaves and their absence on older foliage. The cuticle thickens as the leaf grows older and this may account for the immunity of older leaves to blister blight infection. The cuticle by reason of its thickness and toughness becomes impermeable and impenetrable.

Below the upper epidermal cells is a layer of palisade cell, which owe their name to the palisade-like structure. The manufacture of food is mostly confined to this layer and these cells are very fully stocked with carbohydrates. On older leaves there may be two or even three layers of palisade tissues. Below the palisade layer and between it and the lower epidermis are irregular-shaped cells which constitute the spongy-tissue or spongy parenchyma. There

are wide intercellular spaces between these cells which are ideal for the formation of the fruiting bodies of the blister fungus. That is why the fungus appears on the lower surface of tea leaves — the area of least resistance.

To revert back to germination. As the germ tubes and appressoria grow a thin film of mucilage is formed around them, causing their adherence to the leaf or other surface (Fig. 4). The firm attachment of the appressorium to the leaf is of the greatest importance because the next stage in development is the formation of a very fine thread or infection tube at the point of contact with the leaf (Fig. 5). This infection thread forces its way into the leaf through the cuticle but, if the appressorium was not firmly attached, the pressure exerted would cause it to lift and entry could not then be achieved. At this stage of development the spore itself is completely depleted of protoplasm, or food material, which passes into the appressorium and is cut off from the now empty spore by a dividing cell wall in the germ tube. The time required for germination, formation of the appressorium and penetration into the leaf is approximately 16 hours.

If the spore falls on a suitable leaf, and penetration through the leaf cuticle is achieved, the fungal tube widens out within the epidermal cell. At this stage the fungus is independent of external conditions, as the future growth is entirely within the leaf and all necessary food and water are obtained there. Fungicides at this stage are not effective as the growth is sealed from outside influences by the leaf cuticle.

The infection tube from the appressorium passes through the epidermal cell without branching but branches extensively within the next layer of cells near the point of entry. (Fig. 6). Later growth is, however, almost entirely between the cells or intercellular, and extends for some considerable distance to invade a fairly large area. If growth is intercellular the question may well be asked, how does the fungus extract its food from the living cell? Short irregular-shaped or lobed branches enter the cells and extract nutriment but do not immediately kill them. These irregular-shaped organs are termed haustoria or absorbing organs. The cell contents are eventually disorganised and the invaded area becomes visible as a translucent spot, with which all of you are familiar. The time taken for this disorganisation of the cell contents is 8 to 10 days and this accounts for the period taken from infection to the first indication of blister formation — the translucent spot stage. (Fig. 7). Up to this time there is no evidence of the concave depression on the upper surface of the leaf or the swelling on the lower surface.

The invaded cells are now stimulated to further growth — enlargement but not division. This causes the lower surface to bulge and forms the characteristic blister appearance. Obviously the most convenient spot for mycelial development is amongst the spongy tissue, as the large intercellular spaces and the soft parenchyma cells do not offer the same resistance as the palisade layer.

When infection is over 10 days old the formation of the fruiting bodies begins. A dense growth of hyphae, which are in reality the immature basidia, forms under the lower epidermis. Tht hyphae are directed towards the lower surface and are arranged in dense tufts between the parenchyma cells. With growth and pressure of these developing basidia, the lower epidermis is pushed

out slightly and forms small elevations which house the growing fertile hyphae. In this process some of the cells of the spongy tissue are crushed and others dislodged, while the pressure exerted in the leaf becomes greater and greater. This stage may be seen 3-4 days after the formation of the translucent spot (Fig. 8). Externally as a result of the pressure exerted, the lower epidermis and cuticle rupture, leaving exposed the tufts of hyphae which form the whi e fruiting body or hymenium. (Fig. 9). These fertite hyphae or basidia produce spores at their extremities and the process of spore discharge commences.

The duration of spore discharge is governed by a number of factors. Infection with brown blight, which invades and kills the infected tissues, may shorten this period very considerably but, under normal conditions, spore discharge may continue for seven or eight days until the invaded cells become exhausted of food and the blister fungus, finding conditions unfavourable for growth and nourishment, dies.

To summarise, the life cycle of the blister fungus is —

(1) Germination and the formation of the appressorium in a period of 6 to 16 hours. Up to this stage the fungus is very vulnerable to fungicides, desiccation and sun injury.

(2) In 16 hours penetration into the leaf is achieved and the fungus sealed from desiccation or fungicidal action. The spore and appressorium are now devoid of food and the fungus in the leaf has become truly obligate on the leaf tissues.

(3) In 8 to 10 days the first sign of infection is visible as a translucent spot caused by the disorganisation of the leaf cells.

(4) 15 to 17 days after entry into the leaf, that is 7 — 9 days following the translucent spot stage, the fungus breaks through the lower epidermis and sporing commences.

(5) The white blister is very evident 18 — 21 days after infection.

The effects of spraying are only visible after three weeks, as a crop of blisters is the visual result of infection three weeks earlier. If spraying commences a few days after infection blisters will still mature and spore normally. Copper spraying is protective and not curative. Your chief aim should be to commence spraying operations before the advent of a heavy crop of blisters — commencement of your spraying at a late stage serves only a limited purpose as it is essential to keep down blister formation and spore populations to a very low level for efficient protection.

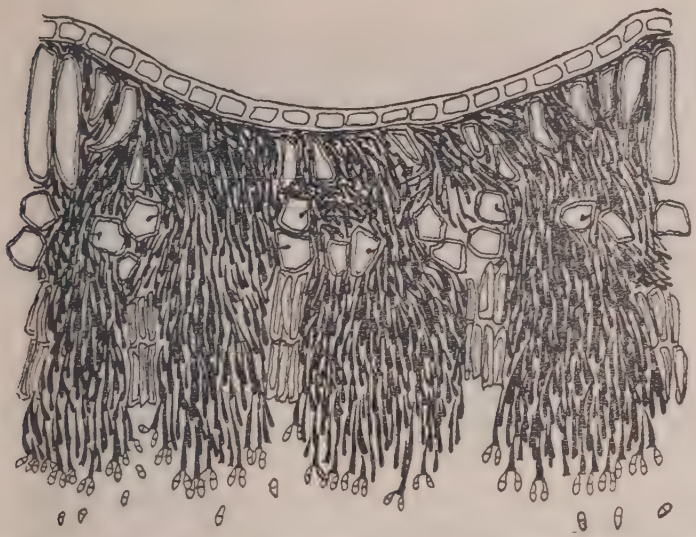

Fig. 2. *Transverse section of a white sporing blister showing concave depression of upper surface of leaf, fungus in the leaf and spores on basidia.*

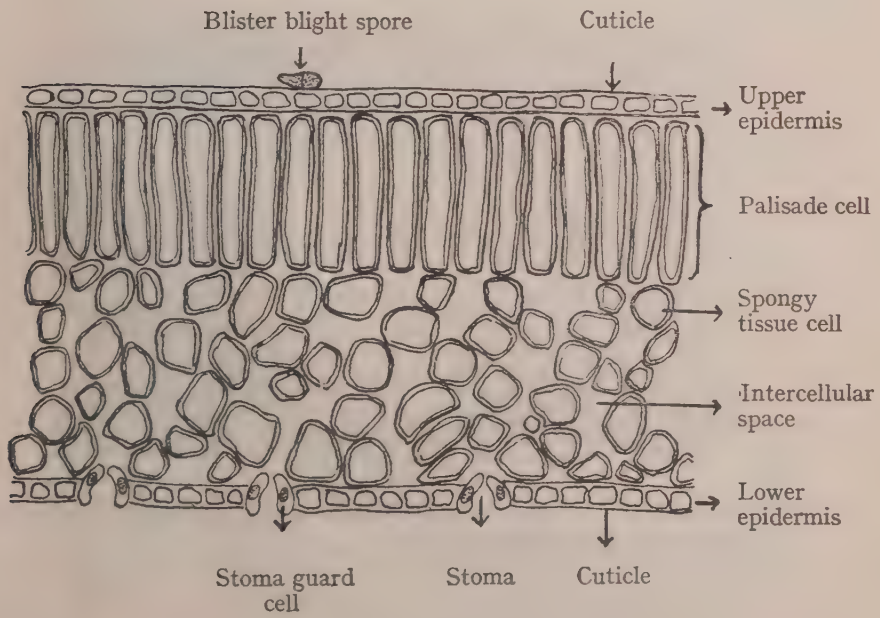

Fig. 3. *Transverse section of young tea leaf showing internal structure. Ungerminated blister blight spore on upper surface of leaf.*

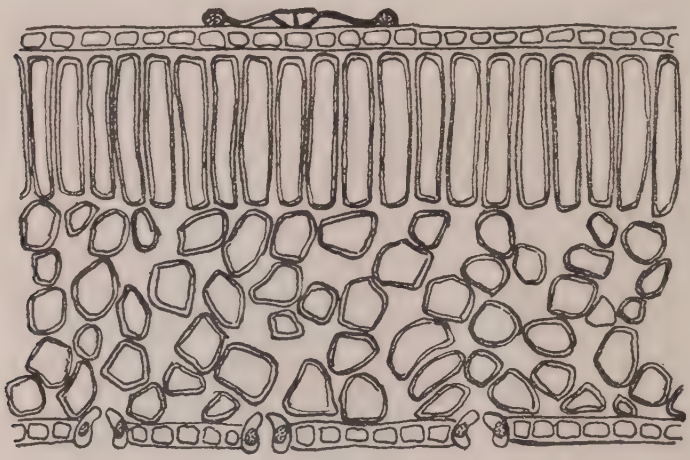

Fig. 4. *Transverse section of young tea leaf showing formation of appressoria of germinated blister blight spore.*

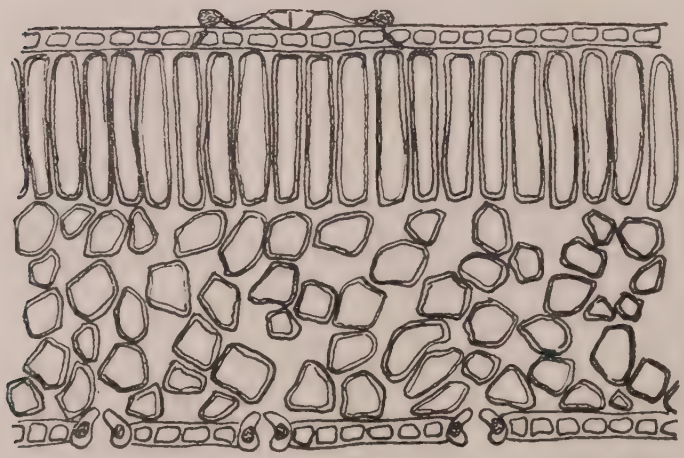

Fig. 5. *Formation of infection tubes from appressoria. Infection tubes have passed through the upper cuticle of leaf.*

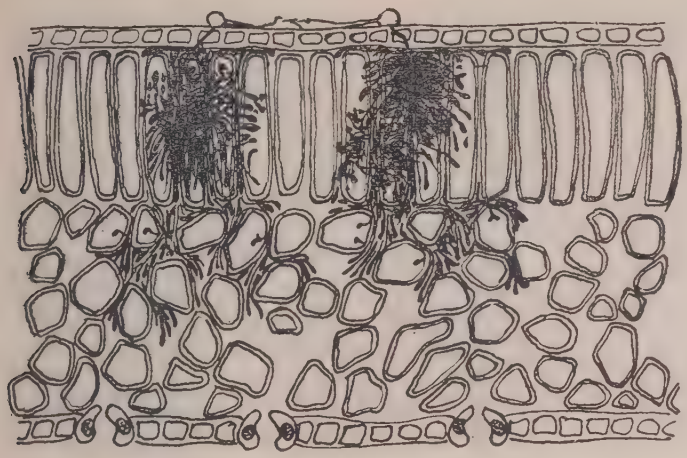

Fig. 6. *Proliferation of the fungus in the leaf tissues — four days after entry into leaf. Note that spore and its appendages have collapsed. The fungus at this stage is obligate on leaf tissues.*

Fig. 7. *Translucent spot stage showing formation of haustoria (food absorbing organs).*

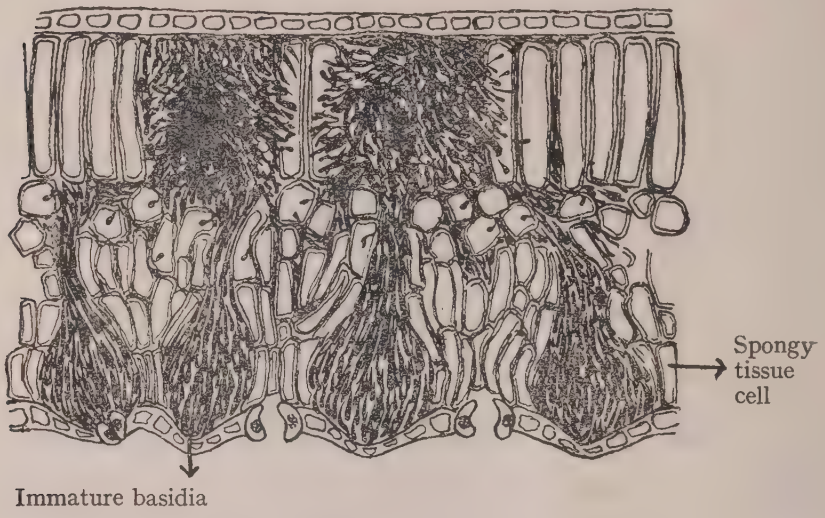

Fig. 8. *Formation of basidia or fertile hyphae. Note elongation and distortion of spongy tissue cells.*

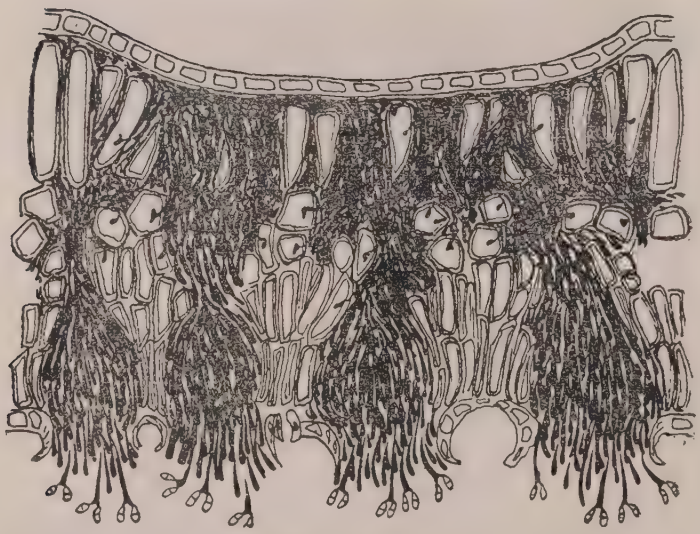

Fig. 9. *Formation of fruiting layer. Basidia have broken through the lower surface of leaf and formation of spores has begun. Note concave depression on upper surface of leaf.*

III. PHYSIOLOGY OF THE TEA BUSH.

By

G. B. Portsmouth.

Introduction.

In this short talk I propose to try and give you some idea of the essential physiology of the tea bush — in other words I want to take you behind the scenes and show you "*how it works.*" A great deal of what I am about to tell you will necessarily be very much oversimplified and much will have to be omitted. However, I am hoping that when I have finished some at least of you will be in a better position to understand the reasons behind our insistence on certain types of agricultural practices and methods of crop protection.

Nutrition.

Before attempting to see how any machine or organism works it is only common sense to find out what it needs to keep it going. In the present case this question resolved itself into asking ourselves what are the nutritional requirements of the tea bush, or, to put it another way, what does the bush have to obtain from outside in order to keep it healthy and growing vigorously ?

The answer is a rather long list of essentials, which may surprise some of you, but any way here it is (Table 1) —

Table 1. *Essential Requirements of the Tea Bush.*

	Source	Function
(1) **Water** (H_2O)	—	Universal
(2) **Carbon** (C)	Carbon dioxide of air	,,
(3) **Oxygen** (0)	Air	Respiration, etc.
(4) **Major Mineral Nutrients**		
Nitrogen (N)	Soils & Fertilisers	Proteins
Phosphorus (P)	,, ,, ,,	Metabolic
Potash (K)	,, ,, ,,	Water Relations
Sulphur (S)	,, ,, ,,	Proteins
Calcium (Ca)	,, ,, ,,	Water Relations
Magnesium (Mg)	,, ,, ,,	Chlorophyll
(5) **Minor Mineral Nutrients**		
Boron (B)	Soil	Growth
Iron (Fe)	,,	Chlorophyll
Manganese (Mn)	,,	Enzymes
Copper (Cu)	,,	,,
Zinc (Zn)	,,	,,
Cobalt (Co)	,,	,,
Molybdenum (Mo)	,,	,,

Some idea of the relative proportions in which the different mineral nutrients are required by the plant can be seen in Table 2, which shows the results of ash analysis of leaf from three different elevations.

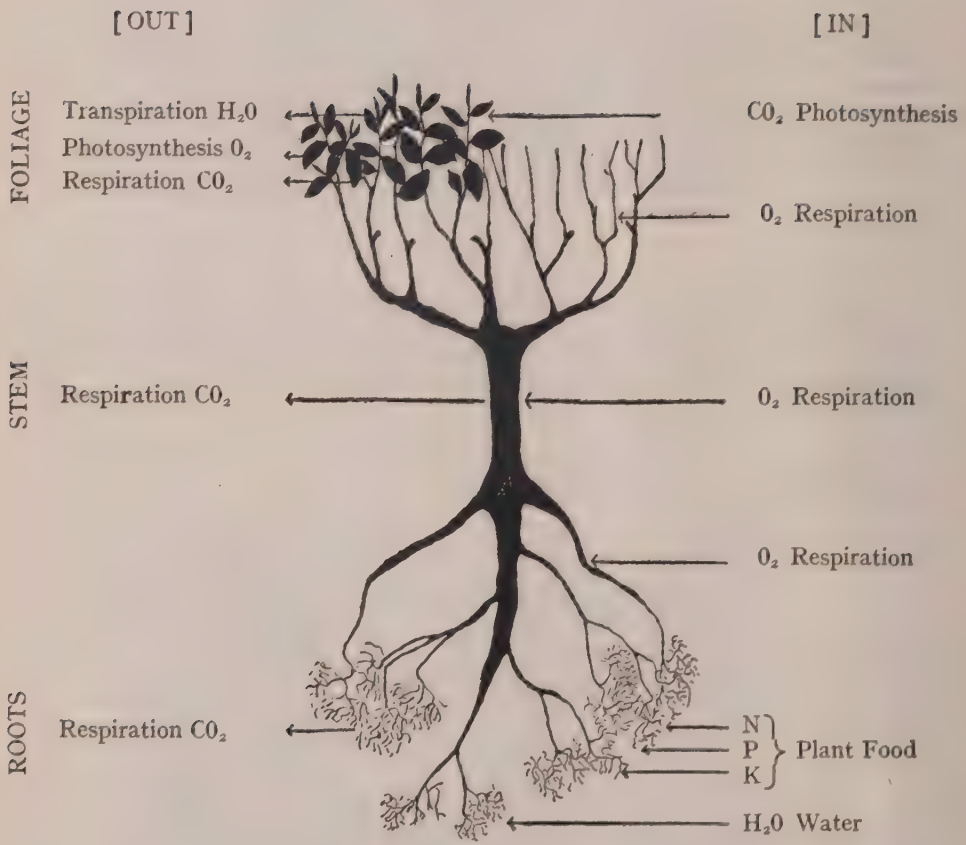

Fig. 1. *Bush Balance Sheet.*

Table 2. *Analysis of Tea Leaf grown at Different Elevations.**

	Low-Country	Mid-Country	Up-Country
Total ash	5.22%	5.13%	4.37%
	Analysis of Ash. Percentage of Ash.		
Potash as (K_2O)	44.22	41.11	44.63
Soda as (Na_2O)	1.15	0.46	0.92
Lime as (CaO)	10.72	13.27	10.80
Magnesia as (MgO)	7.55	7.19	7.25
Iron as (Fe_2O_3)	0.34	0.50	0.51
Aluminium as (Al_2O_3)	2.53	2.44	2.94
Manganese as (Mn_2O_3)	0.49	0.36	0.25
Phosphoric Acid (P_2O_5)	11.86	15.05	18.31
Sulphur as (SO_3)	5.51	4.05	3.82
Silica as (SiO_2)	0.97	0.75	1.56
Chlorides as (Cl)	1.04	1.70	0.84
	The copper content of Ceylon tea leaf varies from25 to 30 parts per million in most areas.		

Carbon, nitrogen and boron do not remain when plant material is ashed and, therefore, do not appear in the analytical results. Copper, zinc, cobalt and molybdenum, on the other hand, are present in such small amounts that they are not detectable by the ordinary analytical procedure. The copper content of tea leaf is, of course, of considerable importance to us at the present time and I have accordingly included some average values, obtained by another method, at the foot of Table 2. These figures are expressed in parts per million, which should give you some idea of the smallness of the amounts normally present. The amounts of the other elements required are, however, very much smaller still and I should expect zinc and cobalt each to be present to the extent of about one part per million, while the molybedenum content may not exceed about one part in one hundred million.

In Table 1 you will see that I have referred to both potash and calcium as being concerned with water relations. In this connection it is interesting to observe that the various analytical figures given for these two elements in Table 2, add up to approximately the same total in every case.

You will note that certain element such as sodium, aluminium, silica and chlorine, which are not essential, appear in the ash. This is because the plant is not one hundred percent selective and so, in the process of absorbing what it needs, also takes up certain unessential elements which are present in the soil. Tea, in particular, readily takes up large quantities of aluminium and, in fact, belongs to a group of plants known as "Aluminium accumulators". This unselective absorption has an important bearing on what is known as "Toxicity", since, if an undesirable element is present in quantity in the soil, the plant may easily take up more of this element than it can tolerate, with the result that toxic symptoms are developed.

Having now, I hope, given you some idea of what makes the plant work let us now try and see how it works.

Water Relations.

First of all let us look at the basic role played by water in the physiology of the tea bush. In the diagram (Fig. 1) you will see that water (H_2O) is taken in by the roots and is given off from the leaves. Between the water-

* *Reproduced from the report of the Chemical Division for the year* 1949. (*Bulletin No.* 31, *p.* 28.)

absorbing roots and the leaves a continuous connection is maintained through the wood, which is the principal water conducting tissue. In this tissue the water moves through special water-conducting "vessels" which are really microscopic tubes or capillaries. This continuous movement of water through the plant has received the name of the "transpiration stream".

On reaching the leaves the water is mainly evaporated from the cell surfaces into the air channels, or "intercellular spaces", within the leaf, and passes out as water vapour through the breathing pores or "stomata" which are dotted all over the underside of the leaf. This process is known as "transpiration." An increase in the rate of air movement over the leaf surface, or a drop in the relative humidity, will increase the rate of water loss from the leaf. Thus, one of the functions of shade is to reduce the amount of water lost by transpiration during periods of drought or high wind.

The evaporation of water from the leaf cells causes more water to enter them from the vessels and creates a "capillary pull" on the water columns in the vessels, which is transmitted right down through the plant to the water absorbing cells of the roots. This causes them to give up some of their water to the vessels and to absorb more water in replacement from the surrounding soil.

This is, fortunately, only part of the mechanism whereby the plant is enabled to absorb water from the soil. The cell sap is not pure water but contains a number of minerals such as potassium and calcium in solution and, as long as the concentration of this internal solution is higher than that outside, water will continue to be absorbed by the root hairs. If it were not for the existence of this second process a clean pruned bush would be unable to obtain any water, since the transpiration stream and its capillary pull are destroyed by the pruning operation. However, with only one water absorbing process remaining, it is now obvious why a pruned bush is more likely to suffer from the effects of drought than an unpruned bush.

Well now that we have got our water entering and leaving our tea bush — what does it do?

Firstly all the mineral nutrients absorbed from the soil by the plant enter in solution in this water stream. These include the familiar N, P, K supplied as fertilisers, as well as the other essential mineral nutrients given in Table 1.

As I have just told you, a pruned bush finds difficulty in absorbing enough water to keep itself from drying out and is certainly not in a position to absorb mineral nutrients as well. This is one of the scientific reasons for the abandonment of the old pruning mixture!

Secondly, water as such makes up some 75 — 80% of all plant tissue, while, in combination as carbohydrates, it accounts for about 60% of the total dry matter as well.

Photosynthesis.

The next most important physiological function with which we have to deal — and one which is specific to green plants — is that of 'photosynthesis." This is in essence the only process which leads to the building up of new organic matter from the simpler inorganic compounds, which are commonly available in the natural environment.

Photosynthesis takes place —

(1) as the name implies, only in the light, and

(2) only in the green leaves (See Fig. I).

It is this latter connection that blister blight begins to assume importance. By destroying maintenance foliage blister reduces the bush's capacity to manufacture new organic matter and to maintain its growth and give us crop.

This, therefore, is one of the reasons why we have always stressed that the initial development of a good canopy of maintenance foliage, protected from blister blight damage, is all important.

Water and carbon dioxide, taken in through the breathing pores on the underside of the leaf, form the raw materials of the photosynthetic process — another name for which is "Carbon assimilation", which should be self explanatory. Reduced to essentials, the basis reaction is one in which 6 molecules of carbon dioxide combine with 6 molecules of water to give one molecule of sugar (glucose) and 6 molecules of oxygen.

$$\underset{\text{(carbon dioxide)}}{6CO_2} + \underset{\text{(water)}}{6H_2O} = \underset{\text{(glucose)}}{(6CH_2O)_6} + \underset{\text{(oxygen)}}{6O_2}$$

The oxygen is liberated into the air, which fact is, of course, the origin of the idea that flowers or pot plants purify the air of a sickroom during the day, but must be removed at night.

The sugars or carbohydrates produced in photosynthesis may be used either as the starting point for building up more elaborate organic compounds, or else may be stored as carbohydrate reserves in the form of starch. If they are to be built up into proteins, then nitrogen and sulphur, two of our major nutrients are required. Furthermore, this is where the plant's requirements of phosphoric acid come in, since the further elaboration of the sugars formed in photosynthesis requires the formation of sugar phosphates, which serve as intermediate products in protein formation.

The process of photosynthesis is brought about solely by the chlorophyll, or green colouring matter of the leaf. This is where the plant's requirements of magnesium and iron come in, since the element magnesium is actually an essential constituent of the chlorophyll molecule, whilst iron is necessary for its initial formation.

Apart from the carbon dioxide, which as I have already explained, reaches the green cells of the leaf through the stomata, all other raw materials reach the leaf through the medium of the transpiration stream. Thus we may expect that the photosynthetic process will be seriously impaired (1) by drought, and (2) after continuous heavy rain, when the leaves become gorged with water and the access of carbon dioxide to the green cells is impeded.

From the leaf factory the finished products are translocated to all parts of the plant by another special conducting tissue known as the "phloem", which need not concern us further.

Before passing on, however, I would like to stress the very important point that some 95% of all the dry matter in the plant is produced in the leaves.

Respiration.

This is the process which provides the energy to keep life going. It goes on in all living tissue — in Figure 1 you will see that I have marked it as occuring in the roots, stem and leaves — and, unlike photosynthesis, it goes on continually — both day and night.

The basic reaction involved is to all intents the reverse of that which takes place in photosynthesis — oxygen is absorbed and used to burn up sugar, while carbon dioxide and water are produced.

$$\underset{\text{(Oxygen)}}{60_2} + \underset{\text{(glucose)}}{(CH_2O)_6} = \underset{\text{dioxide)}}{6\ CO_2\ \text{(carbon}} + \underset{\text{(water)}}{6H_2O}$$

In a normal healthy plant the amount of respiration going on is much greater than is generally realised, and may in fact amount to as much as one tenth of the reverse photosynthetic process. It is, therefore, easy to see that if photosynthesis is cut down; either by adverse weather conditions or by, what is much more important to us, a reduction in leaf surface, then the rate of respiration may well exceed that of photosynthesis. When this happens reserves of carbohydrates will begin to be drawn upon to supply the energy requirements of the living plant. Once these reserves are exhausted protein breakdown will set in, followed shortly by death of the tissues.

Thus once the rate of respiration becomes permanently greater than that of photosynthesis, and all carbohydrate reserves have been used up, there is no hope of saving the bush. However, if the leaf area, although much reduced, is still capable of making more food than is being continually lost through respiration, then the bush can still be saved provided it is rested. If, however, the leaf area of such poor bushes is brought below the danger level by continued plucking or by blister blight attack, then these bushes must inevitably die.

Growth.

Finally just a few words about growth. All natural processes of the plant are affected by temperature. Hence growth is normally faster in the low-country. One of the consequences of this is that nearly all the food manufactured by the leaves is used up in making new growth and there is almost no storage of carbohydrate reserves under low-country conditions. This fact is one of very definite practical importance now that blister blight attacks appear to be increasing in severity in the low-country. With almost no reserves to support new growth, the results of continuing defoliation by blister blight may well be disastrous. In particular, it appears to me to be of paramount importance that low-country tea recovering from pruning in areas subject to persistant blister blight should be given efficient protection if a high casualty rate is to be prevented. Fortunately, such protection can now easily be provided with copper fungicides.

Furthermore, growth cannot go on properly if any essential nutrient element is in short supply. In this connection, the results of a shortage of potash, for example, are now familiar to most of us.

The need, therefore, is for a balanced manurial programme and, above all, for the maintenance of the necessary amount of mature foliage on our bushes. Spray protection during recovery from pruning will ensure an adequate amount of maintenance foliage at the start of the cycle. Provided, therefore, that we treat our bushes carefully during the course of the cycle, I see no reason to fear any further deterioration in capital values. In fact, with proper protection against blister blight, these may well be enhanced.

IV. FUNGICIDES AND THEIR APPLICATION

J. Lamb.

Crop protection now has claims as a separate science and has made tremendous advances in recent years. The first International Crop Protection Congress was held in 1949. The meeting was held in London and was attended by representatives from all over the world.

The main divisions of the subject are:—

1. Control of insect pests.
2. Control of fungus diseases.
3. Control of weeds.

Although our main concern is with the control of fungus diseases, I will attempt to give you some sense of perspective.

Control of Insect Pests.

On the whole this mainly involves eradication, although prophylaxis has a place in crop protection against insect pests.

1. The most desirable approach is by biological control. An example of this is the control of tortrix by *Macrocentrus*.

2. In recent years great strides have been made in the development of amazingly effective chemicals which, at extremely low concentrations, kill a wide range of insects and which leave deposits from spraying or dusting which persist in their toxic effects. Gammexane and D.D.T. are two examples of insecticides with persistent effect.

Insecticides also vary greatly in their effect on different groups of insects. Gammexene and D.D.T. are particularly effective on caterpillars, mosquito larvae and flies.

Some insecticides are mere stomach poisons and have to be eaten — lead aresenate is an example. Gammexane and D.D.T. can act as stomach poisons.

Some kill by contact — Gammexane and D.D.T. are also contact poisons. Other contact poisons depend on volatility and act as respiratory poisons. Nicotine is an example of this class.

Some are gases such as hydrocyanic acid which is used for fumigation.

3. Insecticides based on oil emulsions suffocate insects.

4. The latest development is in systemic insecticides which are absorbed by plants and render their juices toxic to sucking insects for a prolonged period. Some insects, such as scales and aphids, concentrate large amounts of sap and gradually accumulate toxic doses of systemic poisons which are present in the plant in very low concentrations.

Prophylactic insecticides mainly rely on destruction of eggs, as with winter washes, although some leave a toxic deposit which also acts as a prophylatic.

Control of Weeds.

This branch of crop protection has developed enormously in recent years. Modern weedicides or herbicides, as they are now called, are usually cell poisons and cause distorted reproduction or cell division. They are generally absorbed from wet sprays and are highly specific.

In general they have been developed for their toxicity to dicotyledonous plants, or weeds, which grow in monocotyledonous crops — mainly cereals. Cereals belong to the same family as grasses, and since our problem is to control "monocots" in a "dicot" crop, they have not been of much value to us so far.

There are some general weedicides such as sodium chlorate and sodium arsenite, but these are only really useful in fallows and are difficult to apply to standing crops.

Control of Fungicides Diseases.

Fungicides are much more akin to weedicides than insecticides. A fungus is a weed growing on the crop itself instead of in the soil. There is hope of development through weedicides. Some chemicals are known to be absorbed through the leaves and stems of higher plants without ill effects but are showing signs of being toxic to lower plants or fungi. We therefore hope that fungicides with systemic action will soon become available.

Insects move about and more generally live on the surface of plants and the problem of eradicating them is relatively simple. They walk into the poison traps laid for them. Fungi, on the other hand, are generally only vulnerable during the disposal of infective material — usually spores. Once a fungus has gained entry into the plant tissue it is not usually susceptible to control methods. Fungicides are therefore mainly prophylactic and a fine film of fungicide has to be spread over the entire surface of the susceptible tissue of the plant to give protection.

Similar difficulties do occur with insects, and I give you the example of the shot-hole borer in tea which lives in galleries remote from normal control by insecticides.

The difficulties involved in controlling fungus diseases are therefore considerable and there have been few developments in fungicides comparable with the discovery of the insecticides Gammexane and D.D.T.

However, we hope for developments in the not distant future.
Possibilities are —

1. Fungicides with systemic action.
2. Micro fungi parasitic on the fungi to be controlled. This would constitute biological control and, to some extent, brown blight does exercise a control of blister blight. It can only gain entry to tea through damaged tissue and crowds out blister blight and prevents sporing. Unfortunately, when it does gain entry it damages more tissue than the comparatively circumscribed blister.

At the present time fungicides are mainly inorganic.

I. Inorganic Fungicides.

Inorganic fungicides are most often compounds of mercury, sulphur or copper.

1. **Mercury Salts.** Mercury salts are generally extremely poisonous. They are usually too poisonous to both higher plants, and animals which consume them, to be used as sprays. Mercuric chloride, in concentrations as low as 1/10,000, is very toxic to most fungi but scorches badly. It is also very soluble and washes off in rain.

Complex organic compounds containing mercury are widely used as seed dressings to check seed borne disease and to afford protection during germination.

(*Culture tubes with dressed and undressed tea seeds were demonstrated.*)

2. **Sulphur.** Sulphur in the elementary form is very toxic to many fungi. It has very little action on most higher plants and is insoluble and rainfast. Various compounds of sulphur are much more effective than elementary sulphur but are more liable to cause scorch. Elementary sulphur does not control blister blight but lime sulphur gives a reasonable degree of control. Lime sulphur however causes very marked taints in tea.

3. **Copper.** Copper salts are very toxic to most fungi but soluble forms such as copper sulphate scorch plants and are not rainfast. Insoluble compounds such as cuprous oxide and copper oxychloride retain their toxicity, are innocuous to most higher plants, and are highly insoluble in water. They are presumably sufficiently soluble in dew and rain to kill spores at some distance from the actual particles of copper.

This is illustrated by the control of fungus growth on culture plates at some distance from a small spot of copper fungicide.

(Petri dish cultures were demonstrated).

The blister blight fungus, *Exobasidium vexans*, is extremely susceptible to copper fungicides. Provided they are finely divided, and evenly distributed, copper fungicides give a very high degree of control.

II. Organic Fungicides.

The number of organic fungicides becoming available is increasing almost daily. They are proving to be highly specific in action, i.e. to control only one fungus disease, and have important applications in the control of diseases which are not particularly susceptible to copper or sulphur compounds. They are more likely to be absorbed than insoluble inorganic fungicides and are being closely examined for systemic action.

Blister blight is so susceptible to copper fungicides that it will be difficult to find organics which are more effective than copper compounds.

I will therefore now confine myself to a description of copper fungicides.

Copper Fungicides. The first use of copper fungicides was (generally supposed to be) in the wine growing district of Bordeaux. The toxic or scorching effect of copper sulphate was greatly reduced by forming a complex insoluble compound with lime.

Freshly made Bordeaux mixture is still one of the most effective copper fungicides. Its efficiency falls off rapidly after mixing and it settles very rapidly. Bordeaux mixture adheres to foliage very well but does not spread easily.

(Demonstration).

Burgundy mixture is made by substituting washing soda for lime. This spreads more easily but does not stick so well. A similar fungicide may also be made with ammonia or ammonium carbonate. These home-made mixtures are troublesome and have to be made up carefully. They deteriorate quickly, settle rapidly and are very corrosive to equipment.

Modern proprietary formulations are more satisfactory in commercial practice. They are mostly manufactured from the insoluble compounds cuprous oxide and copper exychloride.

The manufacture of fungicides from cuprous oxide and oxychloride is a matter of technical skill and control.

1. They must be extremely finely ground. It is obvious that for 5 ozs. of fungicide to be able to spread evenly over all the upper leaves in an acre of tea it must be ground to an extremely fine state of division. The chemical

activity of most substances increases with grinding and this is apparently the case with fungicides.

2. They must disperse in water quickly and easily and remain in suspension for long periods. This is again a matter of grinding but the incorporation of wetting agents is of considerable assistance.

(Demonstration).

3. They must spread easily over plants when sprayed in water suspension. The incorporation of wetting agents assists them to spread. The wetting agent also causes the water in which the fungicide is suspended to form smaller droplets, i.e., increase atomisation. Fine atomisation is essential where low volume spraying technique is employed.

4. They must stick to plant surfaces and not wash off too easily in rain. Again the finer the state of division, the better the adherence but chemicals known as "stickers" are also added in many preparations.

So for, I have assumed that the fungicide is to be dispersed in water. When water is used as a vehicle, I must stress the importance of fine atomisation to obtain the full benefit of the processing into fine particles. The full benefit of extremely fine grinding cannot be obtained with coarse sprays and I will deal further with this matter in my lecture on application. The incorporation of wetting agents with the fungicide helps to improve atomisation.

(Demonstration).

Dusts. Instead of water, substances also finely ground, such as china clay or kaolin and french chalk or talc may also be used as vehicles for copper fungicides.

The requirements in this case are:—

1. A finely ground carrier which floats in wind currents and which adheres to plant foliage.

2. Processing in such a way that the copper compounds adhere to the carrier and do not merely winnow out.

Unless these requirements are met, control will be very poor and the distribution very faulty.

Mists. Although suspensions of finely ground copper fungicides may be finely atomised and blown in air blasts as mists there are two complications.

(a) Fine atomisation of water is difficult.

(b) Finely atomised water evaporates very quickly.

There are possibilities for mechanical ejection of mists from power operated machines but effective ranges will be limited. The most favourable conditions will exist in the south west monsoon when humidity is high and wind currents are available to carry the mist.

A further possible development of this technique is the oil mist. Clean Crops Ltd.'s Micron sprayer is at present based on the possibilities of very fine atomised oil. Light oils atomise much more easily than water and do not evaporate at the same speed. We are exploring the possibilities of oil soluble copper compounds. Materials in solution are divided into molecules, which state of division is impossible by mechanical grinding. Copper napthenate which has limited solubility in oil is at present under test. We hope that other oil soluble copper compounds will be available this year.

(A film entitled Modern Copper Fungicides, loaned by Plant Protection Limited, was shown at this stage of the lecture).

The Application of Fungicides.

The film called "Atomization", loaned to us by Shell Company, which is to follow this lecture, will explain many points much more clearly than I can hope to do by lecturing. The point I wish to make is that low volume spraying is an exact technique and that the equipment must be carefully chosen and operated under controlled conditions. Above all, I wish to emphasise that a spray nozzle is not merely a hole drilled into a piece of brass.

The main difficulties with the application of fungicides at low volumes are :—

(a) we wish to distribute 5 ounces of extremely finely ground fungicide particles as evenly as possible over an enormous surface area.

(b) to do this, we must have very fine droplets to get the best distribution possible and to get a quick dry, if possible.

(c) since water is heavy, and not always readily available, we wish to use as little as possible.

(d) as we are frequently up against high winds, the spray must not be so fine as to drift away too easily.

At the present moment the most practical compromise is the pressure retaining knapsack equipment fitted with a nozzle which will give a moderately fine spray at an output of 10—12 gallons per acre. The main disadvantage of the knapsack type of equipment is that as the spray fluid is exhausted, so the pressure within the knapsack gradually falls. The nozzles to be used with such equipment in Ceylon are designed to operate over a pressure range of from 40 to 80 lbs. per square inch. It is most important that you should realise that the spray nozzles are specially designed to give uniform results over this specific range of pressure. Figure 1 illustrates a simple type of spray nozzle.

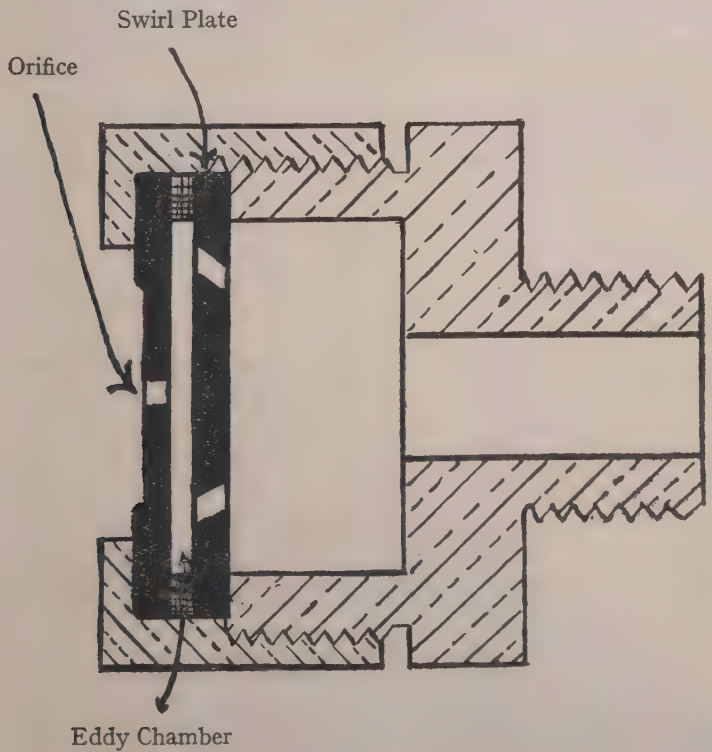

Fig. 1. *A simple type of spray nozzle.*

There are many variations and modifications of this so called "swirl atomization" type of nozzle but the basic principles are the same for all types. In Table 1 are given a list of the various factors which influence the character of the spray issuing from a swirl type of atomiser.

Table 1. *Spray Factors.*

I. Amount ...	...	(a) Orifice (b) Pressure (c) Depth of Eddy Chamber
II. Droplet size ...	...	(a) Pressure (b) Swirl plate (c) Depth of Eddy Chamber
III. "Carry" ...	...	(a) Pressure (b) Droplet size (c) Swirl Plate
IV. Shape ...	...	Orifice

I am indebted to Mr. F. W. J. Lane of Plant Protection Limited for the following summary of the principal points in connection with swirl atomisers :—

(A) **Output.**

A number of simple factors contribute to the amount of spray passing through the nozzle in any given period of time. These are :—

(1) *The size of the orific.* The only function of the size is the control of the amount of fluid passed. It does *not* determine the droplet size of the spray.

(2) *The pressure.* The greater this is, then the greater the output and *vice versa.* This is, however, not in direct proportion. For example :—

Pressure in lbs. per square inch.	30		60		90
Output in gallons per hour.	7.2	diff. 1.8	9.00	diff. 1.5	10.5
Diameter of orifice	.032"				

As the pressure increase so does the output, for each successive increase, decrease.

(3) *Depth of eddy chamber.* The greater this depth the greater the rate of flow and *vice versa.*

(B) **Droplet Size.**

Factors determining droplet size are :—

(1) *Pressure.* Increased pressure will cause increased atomisation.

(2) *Design of swirl plate.* A swirl plate drilled or slotted with small holes round the periphery will place a greater interference on the straight flow of the fluid than will larger holes and will result in a finer spray being projected, i.e., the swirling effect is increased.

(3) *Depth of eddy or swirl chamber.* The greater the depth of this chamber then the less will be the interference in the flow of the liquid to the orifice. In this case larger droplets will emerge from the nozzle than would be the case if the depth of the chamber was small.

(C) **Carry.**

Factors determining "carry" of spray :—

(1) *Pressure.* The higher the pressure the greater the "carry" for any given size of droplet.

(2) *Droplet size.* Large droplets will "carry" very much further than small droplets if the same amount of energy is imparted to each. Try throwing a pebble and then a grain of sand.

(3) *Design of swirl plate.* If a central hole is drilled in a swirl plate, already fitted with holes round the periphery, it will be found that the droplets will be coarser and the spray will carry further.

(D) **Shape.**

(1) There are two types in common use. Firstly, the simplest in design which gives a flat fan shaped spray and the second, a little more complex, which can be made to give sprays ranging from a wide hollow cone to a straight jet of water.

(2) For the nozzle giving a flat fan shaped spray it is claimed, correctly, that a wider distribution of the spray is given for each gallon of liquid passed through it. The hollow cone type enables a wider variation in types of spray pattern to be achieved but the swathe width is narrower than is the case with the fan shaped spray. There is normally less drift with this type of nozzle.

(3) The nozzle giving the flat fan shaped spray consists of a body to hold the component parts, a fine mesh filter and a filter body and an orifice tip. The orifice itself is usually eliptical in shape and this determines the shape of the spray.

(4) The hollow cone nozzle consists of a body for the components. A metal orifice disc which, in the better made equipment, is usually of hardened stainless steel. A brass (usually) disc is positioned immediately behind the orific disc and separated from it by a brass or rubber washer. This is known as a swirl plate and there are many designs to give a variety of types of spray. The space between the orifice disc and swirl plate is known as the swirl or eddy chamber and is an extremely important item in determining the ultimate shape of the spray.

It is therefore obvious that the nozzles used with knapsack spraying equipment must be specially chosen. They must be designed to operate efficiently over a chosen range of pressures. The washers and fittings, in componenfs such such as eddy or swirl chambers, are of exact dimensions and must be replaced with correct spare parts. Assemblies must be kept in good order and orifices must on no account be cleared, if blocked, by hard wire or steel needles which are liable to distort the shape. A blocked orifice plate or tip should be replaced in the field, by a spare part and later cleaned by soaking or boiling.

Orifice plates or tips should be replaced as soon as they show signs of wear, as it is very false economy to use them once the output or character of the spray shows a marked change.

The employment of suitable equipment is of paramount importance. Pressure retaining equipment is more efficient because the mechanical efficiency in pumping a non-compressible fluid such as water is much higher than in pumping a highly compressible fluid such as air. When recharging with fluid is carried out with a central charge pump the correct pressure is much more likely to be maintained than when individuals are responsible for pumping a recharge of air with a "built-in" pump.

V. FIELD ORGANISATION

by

G. B. Portsmouth.

Introduction.

At the outset of this talk I must confess that I am very conscious of having bitten off a great deal more than I can chew. Our own experience of any large scale spraying operations at the present time derives solely from the 200 acre spraying experiments on tea recovering from pruning, which we carried out on Kataboola Group during the last south west monsoon. Many of you coming from north east monsoon areas have, however, already had practical experience of large scale spraying operations on tea in bearing and may, therefore be in a much better position to give advice on this subject than I am. Anyway, bearing my own limitations in mind, I propose to try and put before you such information and suggestions as appear to me may be of assistance to you in developing your own field organisation.

Before getting down to detail I would like to stress the very important fact that, with wet spraying the greater part of the cost of protection is the cost of labour involved. At our last conference I quoted figures showing that over the whole 200 acres of the Kataboola experiment the average labour employed per acre per round was 0.85. At the present rate of Rs. 2.19 per day, this means a labour cost of Rs. 1.86 per acre, whereas the cost of 5 ounces of Perenox, at 12 cents per ounce is only 60 cents. In other words labour makes up more than 75% of the total cost of Rs. 2.46. Here then is an obvious reason why good field organisation, leading to a reduction in the amount of labour required per acre, is all important if costs of spraying are to be kept down.

Another point which must be clearly understood at the outset is that in the spraying of pruned tea and in that of tea in bearing we have quite different objects in view. In the first case, that of pruned tea we want to give individual protection to each bush, whereas in the second case, that of tea in bearing, our object is to protect an area.

These two different aims naturally involve differences in technique and I, therefore, propose to deal with the features peculiar to each type of spraying before discussing the general principles of organisation which are common to both.

Spraying of Pruned Tea.

Dealing first with pruned tea, and bearing in mind that our aim is to give individual protection to each bush it is evident that the single lance is best fitted for our purpose. Accordingly, at this stage the Tea Research Institute cannot recommend the use of anything except the single lance for spraying pruned tea, neither, as stated in Circular No. B.B.3, can we recommend the use of a spray concentration containing less than 4 ounces fungicide in 10 gallons of water.

Disposal of prunings is one of the particular problems associated with pruned tea. At Kataboola and elsewhere it was generally found advisable to have all the prunings piled into alternate rows before spraying operations started.* This leaves every other row clear and enables the spraying labourer to move forward along these rows without encountering any unnecessary obstructions.

** NOTE. The sowing of green manures will have to await removal of these prunings.*

Photo by R. Gilliat.

PLATE II.

Spraying of tea in bearing. Close up of 4-nozzle booms in action during demonstration on Hantane Estate, Kandy.

Photo by R. Gilliat.

PLATE III.

Spraying of pruned tea. Close up of single lance in action during demonstration on Hantane Estate, Kandy.

As he moves down his cleared row the labourer should spray the lines of tea on each side of him. The procedure is for him to first spray, say, two bushes in the left hand line, then two in the right hand line and then move on and repeat for the next two pairs of bushes and so on, particular care being taken to ensure that no bushes are missed out.

In spraying each individual bush the labourer should move his lance tip with a side to side and slightly circular motion over the top of the frame, so that both sides of each branch get properly covered with spray fluid.

The rates of progress of each labourer down their particular rows will undoubtedly vary due to the variations in the size and number of bushes and also with the skill of the operator concerned. Accordingly, it would appear to be most inadvisable to attempt to keep the spraying gang together in line abreast, since the rate of progress of the whole gang will be limited to that of the slowest worker. In this type of spraying, therefore, it is best to allow the labourers to work individually. This requires that each man should be allotted his own particular task, either in the form of a specified number of rows, or else a definite block of tea between certain paths or drains.

Labourers should return individually to the charge pump for refilling. In this connection, the amount of time wasted in walking to and from can be much cut down by keeping the areas to be sprayed by the different members of the gang as close together as possible and siting the charge pump at a convenient central point.

Labourers should also be provided either with a stick or a piece of red cloth each to mark the points at which they have left of spraying.

In blister blight weather spraying should start within two or three weeks of pruning if bud infection is to be prevented. The lighter the type of pruning the earlier spraying should start. A second round about 4 days after the first is probably desirable, if it can be managed, after which the spraying rounds can be at 7 day intervals. Application rates should be about 12 gallons per acre to start with and may be expected to increase to about 17 — 18 gallons per acre by the time the bushes are ready for tipping.

Spraying of Tea in Bearing.

As I said earlier the problem of spraying tea in bearing is one of covering a large area as quickly and efficiently as possible. We do not need to give individual attention to seeing that both sides of a branch are sprayed or that the underside of every leaf is coated with spray fluid. What we have to do is to ensure that the exposed surface of the plucking table is given an even and sufficient coating of spray fluid. Here, therefore, where the lie of the land permits, we can put aside the idea of treating each bush individually and adopt the principle of laying down a uniform cover by passing a continuous curtain of spray straight across the tops of our bushes.

That is in effect the idea behind the method of boom spraying, so effectively developed by Mr. Williams on Ragalla Group during the recent north east monsoon. Most of you will already have studied Mr. Williams's description of his method which we sent out as Circular No. B.B.2. This contains much more detailed information than I can possibly give you today and, if some of you have not already read it, I most strongly recommend it to your attention. In particular, I would like to mention that by using this method Mr. Williams succeeded in spraying as much as 2.8 acres per labourer employed at a cost as low as Rs. 2.21 per acre per round, which are considerably better figures than we were able to achieve in our own experiments.

For spraying of normally spaced tea the 4 foot boom fitted with 4 nozzles, of which a diagram is given in Circular No. B.B.2., would appear to be quite satisfactory. When held at the correct height above the plucking surface, and

moved slightly from side to side, the boom produces a curtain of spray which completely covers two lines of bushes.

For this type of spraying the field organisation is necessarily based on very different principles than when using a single lance, since in the present case the emphasis is all on team work. In his operations Mr. Williams found that a team of 12 actual spraying labourers was about ideal. The men were divided into gangs of 6 each and whilst one gang was charging up the other was spraying. Each operation takes approximately the same time.

When actually engaged in spraying the 6 operators work as one unit and keep in one straight line. This provides a continuous wall of spray across all the 12 lines of bushes being sprayed and at the same time ensure that the same application rate is maintained for each line of bushes. The kangany in charge of the operation walks about 15 yards behind the sprayers and it is his duty to keep the men in line and regulate their rate of walking to give the correct application rate per acre. He must also see that no bushes are missed when booms are manoeuvered around shade trees, etc.

When one knapsack begins to lose pressure all are stopped and the other gang takes over. The kangany remains in the field while the change over takes place. Before leaving the field for recharging, the old gang mark the last sprayed bushes with red cloths, which are picked up by the new gang. The kangany also carries a box of jets and a spanner. When a blockage occurs the whole team is stopped while the dirty jet is replaced — about 1 minute's work.

Here again it is most important to place the charge pump near enough to the actual area being sprayed to prevent any loss of time in walking to and fro. The time available for charging a total of 6 knapsacks is only about 10 minutes, since a 4 nozzle boom will completely discharge a knapsack in slightly less than this. Accordingly, every effort must be made to cut the time lost during changeovers if a large daily acreage is to be achieved. Thus the use of two charge pumps at the same point may even be advantageous. They must not be allowed to remain too long in any one place, but should be moved along as far as possible so as to keep close to the scene of operations.

Boom spraying may not be possible on very steep or difficult terrain and, in these cases, it should not be attempted and the method of single lance spraying, as recommended for pruned tea, must be resorted to. This is a question which must be decided on local knowledge. If in doubt, try out boom spraying for a few rounds and see whether a reasonable acreage per labourer and output of spray fluid per acre can be achieved. If this proves impossible, then you should revert at once to single lance spraying.

An important organisational point in connection with spraying of tea in bearing is the co-ordination of spraying and plucking rounds. In order to keep copper residues within the permissible limits spraying should be done immediately after plucking, thus allowing the longest possible time between spraying and harvesting the leaf. This may well entail some reorganisation of plucking if spraying operations are to proceed according to a regular programme.

With double boom spraying application rates of about 17-18 gallons per acre are to be expected. Single lance spraying may require only 12-13 gallons per acre.

General Considerations

At this stage I propose to move on to certain aspects of field organisation which are common to both types of spraying. Unfortunately these include subjects such as organisation of water supplies, supervision, etc., which, from the very nature of things, must vary from estate to estate and, accordingly, I can do little except suggest to you certain lines upon which these problems might be tackled.

The provision of water supplies is undoubtedly one of the most difficult problems in many fields and a satisfactory solution is well worth looking for since the ready availability of water, where and when required, is likely to do much towards reducing labour costs. Some of the possible ways of providing sufficient water where needed are as follows:—

(1) Diversion of existing streams.

(2) Damming of small streams or springs.

(3) Sinking of 40 gallon drums or other suitable containers in field drains.

(4) The use of specially constructed water transporters for moving water along paths and roads. These may range from 40 gallon drums on hand trolleys, or bullock drawn water tanks, to specially fitted lorries carrying 300 to 400 gallons per load. A lorry fitted with 9 old oil drums, all inter-connected by 2 inch pipes, and carrying nearly 400 gallons of water was actually used throughout the Ragalla spraying operations.

In all cases where such special water containers are to be used it is advisable to arrange for special filling points, where refilling can be carried out rapidly through large bore piping, or otherwise much valuable time may be wasted.

(5) It may prove possible to install standpipes and cocks in suitable positions on existing water pipe lines. This was actually done on Diyagama for last year's spraying of pruned tea.

In this connection the lack of satisfactory roads and paths may very greatly increase the difficulties of obtaining sufficient water for spraying in the more inaccessible fields and so inflate costs. In these cases any increased expenditure incurred in the improvement of roads and paths may be expected to markedly reduce spraying costs and so pay for itself within a relatively short time.

Another subject which is worthy of consideration is that of spares. Adequate supplies of all necessary spares should always be on hand in the field, so as to eliminate any loss of time due to breakdowns. Blocked tips or leaky washers can be changed on the spot by the kangany, but major repairs must not be attempted in the field. If a knapsack, lance or boom gives trouble it should be immediately replaced by a spare unit, so that the work can proceed with the minimum of interruption.

Now a few words about supervision. Good supervision is essential if a high standard of work is to be maintained. Money spent on supervision is money well spent and does not amount to very much per acre per round provided it results in efficient organisation. To quote Mr. Williams once again — his supervisor was paid Rs. 7.50 per day but, when spread out, the cost of supervision amounted to only 7% of the cost per acre per round, or approximately 15 cents, which is again lower than our Kataboola figure. The Kataboola experiment was, however, a pioneer effort and we were able to learn from it that supervision is most effective when labour is kept together in large units and not dispersed as small gangs over a number of widely separated areas.

As well as providing for good supervision, some thought must be given to the comfort of the labourers themselves. Carrying a knapsack all day under monsoon conditions is, to say the least, a somewhat depressing occupation. Accordingly little things, such as providing supplies of hot tea with plenty of sugar during the course of the day are likely to go a long way in stimulating keenness and improving the standard of work. The cumblie is also an awkward garment when carrying a knapsack, so that the provision of some type of jacket, such as we had made up for use on Kataboola, may also be worth considering.

Two other points require mention today as they have been brought up frequently in discussions at the previous courses of this series. The first is that many superintendents appear to be afraid that the figures of costs per acre per round, which have been quoted at various lines by the Tea Research Institute, may be accepted as target figures by Agency Houses. This matter has already been referred to by Mr. Lamb in his introductory talk and I merely wish to assure you that it was certainly never our intention that any figures we have given you should be taken as applicable to all estates. Where difficult terrain, poor availability of water and poor roading, either singly or in combination, present serious obstacles to developing an efficient organisation, then costs per acre per round may be expected to be considerably higher than any which we have so far published. Where easy terrain, ample water and good roads exist, on the other hand, I am confident that good organisation may be able to produce still lower cost figures than the best obtained to-date.

The second point is that some superintendents appear to be having a certain amount of trouble in estimating their requiremtnts of fungicide for the coming season. I have accordingly worked out the approximate amounts of fungicide required per acre per round for the different spraying methods and tabulated the results in a new Circular No. B.B.B., which has now been sent out to everyone on our list. As a rough guide a requirement of some **6 ounces of fungicide per acre per round** is likely to be approximately correct.

Finally, as I have said once before, many of the problems of field organisation are problems peculiar to the estate concerned. We cannot at this stage produce a general blue print showing how to spray, and, even if we did, I am afraid much of it would not be applicable to individual problems. The best advice I can give you is the old army one, which is first make an appreciation of the situation, and then prepare your operational plan, which should be subject to modification in the light of actual experience.

VI. AN ESTIMATE OF THE EXTENT OF CROP LOSSES ON ST. COOMBS FOLLOWING THE ARRIVAL OF BLISTER BLIGHT (*EXOBASIDIUM VEXANS*) IN CEYLON.

G. B. Portsmouth.

Arising out of discussions at the 1951 Crop Protection Courses, it occurred to the writer that an examination of the yields of the long term field experiments on St. Coombs offered what was perhaps the only possibility of making a reliable estimate of the extent of the crop losses occasioned by blister blight in one specific locality. Full yield records are available for these experiments, which probably represent the only areas of tea in Ceylon where cultivation and manuring treatments have remained unchanged for a long enough period for their effects to be eliminated from the estimate.

Blister blight was first reported from the Dimbula district, in which St. Coombs is situated, in November 1946 and by early 1947 had to all intents and purposes, spread over all the tea area in Ceylon (1). On St. Coombs, therefore, it may reasonably be assumed that the disease would not have begun to cause damage until the south west monsoon season of 1947. Accordingly, as blister blight damage is likely to have a cumulative effect during the course of the

cycle, it was necessary that any experiment selected for comparison purposes should have started a new cycle early in 1947. This condition was fortunately fulfilled by the Cultivation and Weeding Experiment on St. Coombs No. 9 field.

This experiment was laid down in 1936 and has a cycle length of 4 years. The treatments compared are :—

Cultivation — Normal versus Intensive.

Weeding — Clean versus Selective.

Manuring — Single versus Double dose.

where the single dose is equivalent to the following annual application rates :—

40 lbs. Nitrogen as sulphate of ammonia.
30 lbs. Phosphoric acid as saphosphosphate.
20 lbs. Potash as muriate.

There are 8 treatments replicated 6 times in blocks = 48 sub-plots of 1/24 acre each.

Although it is hoped, in due course, to statistically analyse all the individual sub-plot yields, and thus obtain a reliable estimate of the errors involved; for the purpose of the present article only the main yields of the experiment as a whole will be considered. For various reasons the first cycle is not strictly comparable and it is therefore omitted from the yield comparisons given in Table 1.

Table 1. *Cultivation and Weeding Experiment, St. Coombs No. 9 Field.*

Mean yields in lbs. made tea per acre.

Year	2nd Cycle 1939—43	3rd Cycle 1943—47	4th Cycle 1947—51
Pruning date	March, 1939	March 1943	March 1947
1st	247	248	431
2nd	832	906	843
3rd	1,070	1,140	824
4th	1,128	1,174	601
Cycle mean	819	867	675

The 4th cycle of the experiment was subject to blister blight throughout, whereas both the 2nd and 3rd cycles can be considered to have been completed almost entirely before the advent of blister blight in Ceylon. On the assumption that the Cycle yields for the experiment would have otherwise remained reasonably steady the decline shown in the 4th cycle must be attributed entirely to blister blight damage. The extent of this effect is set out in Table 2.

Table 2. *Cultivation and Weeding Experiment, St. Coombs No. 9 Field.*

Effect of blister blight on yield.

Cycle	Mean Yield lbs./acre	Decrease in 4th Cycle	
		lbs.	Percent.
4th	675	—	—
3rd	867	192	22
2nd	819	144	18
		Mean decrease = 20%	

On St. Coombs, therefore, there is reasonably reliable evidence that, over the past four years, **the loss of crop resulting from blister blight attack has averaged 20%**. If anything this estimate is probably too low rather than too high since it will be seen from Table I that there appeared to be a slight tendency for the cycle yields to increase with time rather than to remain static. Furthermore, as St. Coombs is by no means situated in one of the worst blister blight areas, it is reasonable to suppose that much greater crop losses will have occurred on more badly affected estates.

The St. Coombs No. 9 Field Crop Protection Experiment (2) has now been in progress for a sufficient length of time for the crop returns to afford valuable confirmation of the accuracy of the estimate of blister blight losses deduced from the yields of our Cultivation and Weeding Experiment. The yields from the No. 9 Field Crop Protection Experiment are given in Table 3.

Table 3. *St. Coombs No. 9 Field Crop Protection Experiment.*

Treatment	Yield of Made Tea in lbs./acre 23-7-49 to 20-7-51	Decrease on Weekly Protected	
		Lbs.	Percent.
Protected weekly	1805	—	—
Protected fortnightly	1717	88	4.9
Unprotected	1380	425	23.5

On tht assumption that weekly spraying, under the conditions prevailing on St. Coombs, gives almost complete protection it will be noted that the loss of crop due to blister blight damage amounts to an average of 23.5% over the first 2½ years of the cycle. This figure is extremely close to the figure of 22% given in Table II for the difference in yield between the 3rd and 4th cycles of the Cultivation and Manuring Experiment and thus amply confirms the deductions previously drawn from the yields of this experiment.

These results, for losses of crop due to blister blight, lend strong support to the explanation advanced by Mr. Lamb (3) that the overall yields of Ceylon tea have only been maintained at the expense of much increased fertiliser applications.

References.

(1) A Report on Blister Blight Disease in Ceylon Tea Plantations. *Tea Quarterly* XX, p. 149, 1949.

(2) Loos, C. A.—Crop Protection during Plucking, *Tea Quarterly* XXI, Part IV, p. 16, 1950.

(3) Lamb, J.—Crop Protection Courses, 1951. I. Introductory Lecture, *Tea Quarterly* XXII, Part II, page 55, 1951.

MINUTES OF THE MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD AT 2-30 P.M. ON FRIDAY, 20TH APRIL, 1951, AT THE OFFICES OF THE PLANTERS' ASSOCIATION OF CEYLON, 113, STEUART PLACE, COLOMBO.

Present.—Mr. R. C. Scott, C.B.E. (Chairman); The Director of Agriculture (Dr. A. W. R. Joachim, M.B.E.); The Chairman, Planters' Association of Ceylon (Mr. R. C. L. Notley); The Chairman, Agency Section, Planters' Association of Ceylon (Mr. R. S. Davies); Messrs. V. G. W. Ratnayake, M.B.E., M.P., Errol Jayawickreme, W. Neal de Alwis, J.P., U.M., W. H. Attfield, A. D. McLeod, R. M. Macintyre and J. Lamb (Director and Secretary).

1. Notice convening the meeting was read.

Letters regretting inability to attend the meeting were received from Messrs. L. B. de Mel, A. G. Ranasinha, C.M.G., C.B.E., C.C.S., H. S. Hurst and H. de T. Wilkinson Kay.

2. The Minutes of the meeting of the Board held on 14th February, 1951, were confirmed without comment.

3. **Membership of the Board and Committees.**

(a) **Board.**

The Chairman reported:

(i) That Mr. J. C. Kelly had resigned his seat on the Board as from 31st March, 1951, on his retirement from Ceylon. In expressing the appreciation of the Board the Chairman quoted a letter he had written to the Secretary of the Planters' Association of Ceylon (Agency Section) on receipt of the official intimation of Mr. Kelly's retirement.

He referred to the serious operations on his eye which Mr. Kelly had to undergo and expressed the hope that it would be entirely successful, and that he would soon regain full health and enjoy a long and happy span of retirement.

(ii) That Mr. R. Singleton Salmon, C.B.E., had also resigned his seat as from 31st March, 1951. On behalf of the Board he expressed the thanks of the Board to Singleton Salmon for his services to the Tea Research Institute.

Messrs. R. M. Macintyre and A. D. McLeod, nominated by the Agency Section of the Planters' Association of Ceylon to fill the places rendered vacant by the two resignations, were welcomed to the Board.

(iii) That the three members representing the Low-Country Products Association, *viz.* Messrs. W. Neal de Alwis, J.P., U.M., Leo B. de Mel, J.P., U.M., and Errol Jayawickreme had been renominated by the Low-Country Products Association as from 6th February, 1951.

He expressed pleasure at the renomination of these three members to the Board and expressed the hope that Mr. de Mel would make a quick and complete recovery from his recent illness.

The Board congratulated Dr. A. W. R. Joachim on his appointment as Director of Agriculture.

(b) **Finance Sub-Committee.**

The resignations of Messrs. J. C. Kelly and R. Singleton Salmon had created two vacancies on the above Committee. The Chairman proposed the election of Dr. A. W. R. Joachim as one member. Agreed.

Mr. R. C. L. Notley proposed and Mr. V. G. W. Ratnayake seconded that Mr. W. H. Attfield be elected as the other member. Accepted.

(c) **Estate and Experimental Sub-Committee.**

Messrs. R. H. Horne and G. K. Newton were proceeding on leave; they had both expressed their desire to continue on the committee. Mr. T. Kane had agreed to act for Mr. Horne as on previous occasions.

The Chairman referred to Mr. Horne's recent serious indisposition and hoped that he too would make a speedy return to normal health.

4. **Small Holdings.**

(a) The Chairman briefly reviewed the steps taken by the Sub-Committee which the Board had set up at the meeting held on 18th October, 1950, and referred to the circular letter dated 1st March, 1951, which conveyed the decision of this Sub-Committee. All members of the Board had agreed to the proposal to ask for an increase in the Tea Research Cess by 5 cents, i.e. from 25 cents to 30 cents per 100 lb. tea exported. He said that copies of the letter addressed to the Hon'ble Minister of Agriculture and Lands, dated 6th March. togeher with a report on the small holdings advisory service had been issued to members. He asked members for approval of the action taken. Approved.

(b) It was necessary for the Board to appoint a Sub-Committee to select the new Small Holdings Officer for the Kotmale area. Applications were to close on the 20th April and 185 applications had been received up to the 19th April.

Mr. V. G. W. Ratnayake not being available, Dr. A. W. R. Joachim, Mr. Errol Jayawickreme and Mr. R. C. L. Notley, with the Director as convener were elected to form the Sub-Committee.

(c) There was a considerable demand by small holders for tea seed in small quantities. Last year the Department of Agriculture had subsidised seed imported from Malaya, but this year it was proposed to sell the seed to small holders at cost price so that the Institute would not be involved in any loss.

5. **Staff.**

(i) **Grading Scheme.**

The Chairman explained that the loss of the services of senior officers in recent years had resulted in the Junior Staff having to carry more responsibility. Several promotions had already been made where ability to carry responsibility had been demonstrated. Authority must, however, be given with responsibility and those carrying responsibility should receive adequate remuneration.

Without any radical changes it had been found possible to formulate a clear cut scheme of comparative simplicity.

(1) To provide clearly defined scales to facilitate administration and new appointments and to remove anomalies without any unfairness to present staff;

(2) To provide ample opportunity for promotion by upgrading, with the object of encouraging the staff and preventing stagnation.

(3) To safeguard the Board's interests in the case of employees of limited ability.

Qualifications for new entrants should be :—

Grade I — University degree or equivalent.
Grade II — S.S.C. or equivalent
Grade III (Field) — J.S.C. or equivalent.

(ii) **Procedure for making appointments.**

A letter had been received from Sir Ivor Jennings on the subject of procedure for making appointments.

The Chairman asked the Board to agree to constitute a Selection Committee on the lines set out by Sir Ivor Jennings, i.e. the Chairman of the Board, the Director of Agriculture and the Director of the Tea Research Institute, with one or two experts, either from the Department of Agriculture or the University, co-opted if necessary.

Dr. Joachim agreed to serve, and proposed that Sir Ivor Jennings, or his nominee, and a member of the Board, preferably one suited for the particular appointment, should be appointed in place of the two experts suggested by Sir Ivor Jennings. This was agreed to, and it was also decided that the member of the Board should be selected by the Director in consultation with the Chairman.

6. **St. Coombs Estate.**

The Chairman reported that Mr. F. C. Daniel, the Superintendent, was expected to arrive in Colombo on the 22nd April, 1951. He would take over from the Acting Superintendent on the 3rd May, 1951.

He wished to record appreciation of the excellent work carried out by Mr. Bruce Gibbon, as a result of which St. Coombs estate was in very fine condition. The Visiting Agent had borne testimony to this fact in his latest report.

7. **Junior Staff Provident Fund.**

(a) The Chairman reported that copies of the minutes of the meeting of the Trustees held on 14th August, 1950, together with the rules incorporating the amendments as recommended by the Trustees, had been issued to members. Those rules would therefore need the approval of the Board in order to become operative.

It would interest members to know that the Fund has a membership of 50 which included all monthly paid officers on the Institute's staff. The total assets of the Fund at 31.12.50 was Rs. 281,754-63.

The Board ratified the rules as amended by the Trustees, and expressed their thanks to Mr. Singleton Salmon for his assistance in getting the rules set out in such a satisfactory manner.

(b) **Trustees.**

No stockbroker member of the Board being available, Messrs. V. G. W. Ratnayake and R. S. Davies were elected as Trustees.

8. **Any Other Business.**

(a) **Visit by the Minister of Agriculture and Lands.**

The Chairman reported that the Hon'ble Mr. Dudley Senanayake, Minister of Agriculture and Lands, paid an official visit to the Institute on Thursday, 29th March, 1951. Several members of the Board were present and a full day's programme gone through.

(b) **Crop Protection Courses.**

The Director had arranged for courses of instruction on Crop Protection. These courses, which were being held at present, had to be decentralised owing to the large numbers attending. Over 250 had applied and it had been arranged to hold the courses at Radella, Darawella, Badulla and Kandy.

(c) **Agri-Horticultural Show.**

The Institute had put up a display of spraying machinery and other items of interest at the Agri-Horticultural Show held in Nuwara Eliya during Easter week.

(d) **The Ceylon Planter's Society.**

The Ceylon Planters' Society had made a request to the Tea Research Institute to hold a special field day on the morning of the 19th May for the benefit of Planters attending the meeting of the Society, which was to be held at Radella in the afternoon of that day. The Director had agreed to co-operate.

(e) **Director's leave.**

The Chairman formally proposed that the Director be granted six months leave from 3rd June, 1951. He explained that the Director had agreed to fly back in November in order to prepare the estimates for 1952, and to be present for the two further essential Board meetings. He would then return by air to continue his leave early in 1952. Approved.

The Board expressed their appreciation of the Director's services and wished him an enjoyable holiday.

It was agreed that Mr. G. B. Portsmouth be appointed to act for Mr. Lamb during his absence on leave.

Finally, the Chairman thanked the members of the Board for their assistance in dealing with the unusually lengthy agenda and the meeting closed with a vote of thanks to the Chair.

Sgd. J. LAMB,
Secretary.

Tea Research Institute,
Talawakelle.

NOTICES.

The Institute's Laboratories and Offices are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. M. Y. Hemachandra & Co., Forwarding Agents. *Carriage should be pre-paid.*

Visitors' Days. The *second* and *last* Wednesdays in each month have been set aside as Visitor's Days at St. Coombs Estate and also at the T. R. I. Sub-Station, Gonakelle Estate, Passara, where it is hoped anyone interested will visit the Stations.

Rules for the Occupation of St. Coombs Guest House

(1) The Guest House is normally intended for the use of persons visiting the Institute and St. Coombs Estate on business. Children can in no circumstances be accommodated.

(3) Permission to occupy a room for the night must be obtained from the Director in writing and, unless sufficient notice be given, accommodation cannot be guaranteed.

(3) All visitors must sign the Visitors' Book on arrival.

(4) A bedroom may not be occupied for more than one night if required by another visitor. This shall not apply to Members of the Board or of Committees meeting at St. Coombs who shall also be entitled to priortiy in the allocation of accommodation when on official business.

(5) Complaints or suggestions shall be entered in the book provided for the purpose and not made to the Guest House Staff. All payments due for services rendered shall be made in *cash* to the Guest House Keeper and a receipt obtained from him on the official form. The scale of approved charges is posted in the building. The Guest House Keeper is forbidden to give credit or to accept cheques.

(6) All breakages will be charged for at cost price.